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CJ805 -23 -23B

AFT FAN ENGINE

MAINTENANCE MANUAL

F. A. A.
APPROVED

GENERAL ELECTRIC

COMMERCIAL ENGINE DIVISION
PRODUCT SUPPORT DEPARTMENT

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5	Aug. 1, '63	DER 1-163	7/9/63		
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INTRODUCTION

1. General.

A. **This maintenance manual, in accordance with airline practice, covers the** maintenance that can be performed while the engine is installed in the **aircraft. The manual has been written in accordance with Air Transport** Association Specification 100 and in this form is intended for use along **with the aircraft maintenance manual. Because of this fact the 'continu-**ity of the chapter numbers is broken. Only the information that is to be supplied by the engine manufacturer will be found herein.

B. **It** should be noted that standard shop practice safety procedures and precautionary measures should be observed at all times to avoid damage **or injury to equipment and persons.**

C. These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in **connection with installation, operation or maintenance. Should further information be desired or particular problems arise which are not cover-**ed sufficiently for purchaser's purpose, the matter should be referred to the General Electric Company.

2. Numbering System. The maintenance manual employs a 3-element numbering system. The first dash number denotes the chapter, the second denotes the section, while the third number denotes the subject or item. The following example illustrates the use of the system:

72-1-1

72 denotes the chapter - Engine
1 denotes the section - Compressor Section
1 denotes the subject - Front Frame Assembly

The use of a zero (0) in place of a section or subject number indicates coverage of the entire unit. The following are examples:

72-0 ..... Covers engine as a unit
72-5-0 ..... Covers engine lubrication system as a unit

3. Page Numbers. Page number blocks are assigned to separate the sUbjects into topics. The following blocks have been assigned for the respective topic **uses:**

Description and Operation ..... Page **1 to 100**
Trouble Shooting ..... **Page 101 to 200**
Maintenance Practices **Page 201 to 300**

NOTE: Maintenance Practices is actually a combination of the following sUb-topics: Servicing, Removal/Installation, Adjustment/Test, Inspection/Check, Cleaning/Painting and Approved Repair.

Two systems are used for numbering Maintenance Practices pages. If the sub-topics are brief, they are combined and number pages 201 to 300 used. However if the individual sub-topics are lengthy they are numbered separately as follows:

Servicing.....Page 301 to 400
Removal/Installation.....Page 401 to 500
Adjustment/Test.....Page 501 to 600
Inspection/Check.....Page 601 to 700
Cleaning/Painting.....Page 701 to 800
Approved Repairs.....Page 801 to 900

4. Figure Numbers. **Illustrations are numbered consecutively within each topic** or sUb-topic. The figure numbers are blocked in the same manner as the page **numbers:**

Figures in Description and Operation.....1,2, 3, 4, 5 etc.
Figures in Trouble Shooting.....101, 102, 103, 104, 105 etc.

5. Definitions. The following terms are used in the maintenance manual and are defined as follows:

NOTE: Notes call attention to methods which make the job easier.

CAUTION: CAUTIONS CALL ATTENTION TO METHODS AND PROCEDURES WHICH, IF NOT PRECISELY FOLLOWED, POSE A PARTICULAR RISK OF EQUIPMENT DAMAGE.

WARNING: WARNINGS CALL ATTENTION TO METHODS, PROCEDURES OR LIMITS WHICH, IF NOT PRECISELY FOLLOWED, POSE A PARTICULAR RISK OF INJURY OR DEATH TO PERSONS.

CHAPTER 72 ENGINE

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CHAPTER 72 ENGINE

DESCRIPTION AND OPERATION

1. General. The General Electric CJ805-23 (E-753"O") and CJ805-23B are high performance, low weight axial-flow aft-fan jet engines controlled by a **hydro-mechanical fuel system. High performance is obtained by incorporating a high air flow, high pressure ratio compressor that has a variable stator,** and a single stage aft-fan that is free floating. The light weight of the **engine is the result of several contributing factors, but is primarily dependent on the load-carrying outer skin, conical-type construction of support members, and use of sheet metal construction. When a reference to a specific engine model is required the following will be used.**

CJ805-23 (E-753"O") Engine - CJ805-23 or -23
CJ805-23B Engine - CJ805-23B or -23B

2. Engine Data:

Engine Length -	Front Frame through Fan Rear Frame	129.83 inches
-	Front Frame through Exhaust Nozzle	144.0 inches
Engine Diameter Max	'"	53.34 inches
Engine Weight (Dry)		3800 pounds (approx.)

Additional Weights (estimates):

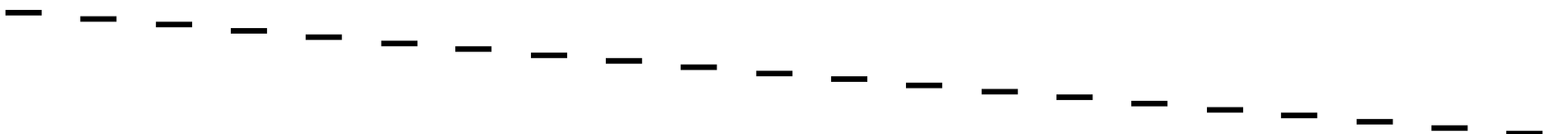
Thrust Reverser and Control System	535 pounds (approx.)

Center of Gravity - Approximately 1/2 inch to the rear of the rear **flange of the compressor rear frame, on longitudinal centerline with reverser removed. With reverser installed, approximately 7 inches to the rear of the rear flange of the compressor rear frame.**

3. Sections of Engine.

There are 7 main sections of the engine; namely, the compressor section, the combustion section, the turbine section, the aft fan section, the accessory drive section, the exhaust section and a lubrication section. The description of each of these is given in the corresponding section of this chapter.

NOTE: The CJ805-23 and CJ805-23B engines are basically the same except where **specified in the manual. Model specifications are not used in cases where the part can be identified by other means.**



ENGINE - TROUBLE-SHOOTING

1. General. Trouble-shooting is a systematic analysis of the symptoms which indicate engine malfunction; these are usually a deviation from normal operating parameters. Since the operating limits section of this manual describes normal engine indications, trouble-shooting is closely related to this information. Since it would be impractical to list all the possible malfunctions which could occur in a modern jet engine, this section will cover only the most common malfunctions. A thorough knowledge of the engine systems, applied with logical reasoning, will solve any remaining problems which may occur. The remainder of this section has been broken down into the following trouble-shooting paragraphs:

NOTE: Refer to either this Engine Maintenance Manual or the Aircraft Maintenance Manual, as applicable, for the sections referenced in the trouble-shooting tables.

Trouble/Symptom	Paragraph
STARTING PROBLEMS	2
Engine Will Not Motor When Starter Is Actuated	2.A.
Unable To Motor Engine Up To Starting Speed (Or Too Much Time To Attain Normal Speed)	2.B.
Unable To Start Engine - Little Or No Fuel Flow	2.C.
Unable To Start Engine - Fuel Flow Satisfactory	2.D.
Engine Fails To Start In Flight But Starts Satisfactorily On The Ground	2.E.
Engine Will Not Accelerate To Idle Speed (Or Too Much Time To Accelerate To Idle Speed)	2.F.
Engine Overtemperature During Start (Fuel FloW Normal)	2.G.
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Engine Has Acceleration Hang-up And/Or Stall During Start" (With Possible Overtemperature)	2.I.
IDLE PROBLEMS	3.
Idle Speed Is Out Of Limits	3.A.
Engine Surges Or Rumbles At Idle	3.B.

Trouble/Symptom	Paragraph
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Engine Unable To Reach Selected Speed - All Engine Parameters Are Low	4.A.
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2. Starting Problems

A. Engine Will Not Motor When Starter Is Actuated.

Possible Cause	Isolation Procedure	Correction
(1) Low starting **air pressure**	Check starter air supply. **Minimum pressure 30 psi.** It should motor the engine to 19% RPM.	Replace ground **starter cart.**
(2) Engine rotor **is bound**	Reach into engine inlet and attempt to rotate rotor by hand.	Usual inspection of **compressor and turbine reveals no damage and engine has** just recently been shut down allow the **engine to cool for two hours.** If the rotor still **seizes, replace engine.**

NOTE: If rotor frees after cooling, turn it by hand and listen for unusual noises. **If none are heard, motor engine with starter and listen for unusual noises. If none are heard, continue normal operation of engine. If unusual noises are noted, determine and correct cause before proceeding. Refer to Abnormal Engine Noise,** paragraph 6.

WARNING: WHEN ROTATING COMPRESSOR ROTOR BY HAND, TARE PRECAUTIONS TO PREVENT HAND BEING CAUGHT BETWEEN ROTATING AND STATIONARY PARTS.

Possible Cause	Isolation Procedure	Correction
(3) Defective starter air valve	Check valve shaft index for position. Should be full open when air is applied.	Replace valve per 80-1-2.
(4) Defective starter	Check aircraft starter.	Replace starter per 80-1-1.
(5) Broken engine radial drive shaft	An overspeed of the engine starter is indication of a defective drive system.	Replace radial drive shaft per 72-4-2.

B. Unable To Motor Engine Up To Starting Speed (or too much time to attain normal speed).

Possible Cause	Isolation Procedure	Correction
(I) Low starting air pressure	Check starter air supply. Minimum pressure 30 psi.	Replace ground starter cart.
(2) Aircraft air bleeds "ON"	Check bleed valve for operation.	Replace bleed valve per 36-1-1.
(3) Defective starter air valve	Check valve shaft index for position. Should be full open when air is applied.	Replace valve per 80-1-2.

C. Unable To Start Engine - Little Or No Fuel Flow.

Possible Cause	Isolation Procedure	Correction
(I) Incorrect rigging of fuel shutoff linkage	Refer to engine controls trouble-shooting, 76-1-0.	
(2) Fire handle pulled	Check position of handle.	Position correctly.
(3) Fuel pump inoperative	Check pump output during prestart operation.	Replace pump per 73-1-1.
	(a) If there is output, pump is good.	Check fuel filter for contamination per 73-1-3.
	(b) If no output, pump is bad.	

Possible Cause	Isolation Procedure	Correction
(4) Faulty fuel control	Other possible causes eliminated.	Replace fuel control per 73-1-4.
(5) Restriction in the fuel lines	Inspect fuel lines for obstructions.	Remove obstruction or replace line.

D. Unable To Start Engine - Fuel Flow Satisfactory

Possible Cause	Isolation Procedure	Correction
(1) Fuel pressurizing and drain valve	Check aircraft drain can for excessive fuel.. If valve is defective, the drain can will overflow.	Replace defective pressurizing and drain valve per 73-1-6.
(2) Ignition system fuses and/or circuit breakers out	Check fuses and/or circuit breakers.	Refer to engine starting troubleshooting 80-1-0.
(3) Faulty ignition system	Switch to alternate system. If engine starts, troubleshoot the faulty system. Verify if igniter plug is firing by energizing ignition system and listening for sound of electrical discharge in vicinity of igniter plug.	Troubleshoot faulty ignition system.
(a) Defective igniter plug	Check for spark intensity. Remove plug from liner, and leave connected to cable. Energize ignition system, and observe spark. A good plug is indicated by a rapid sharp, spark at the center of the plug firing end.	Replace plug found to be defective per 74-2-3.

CAUTION: DO NOT ATTEMPT TO CLEAN THE FIRING END OF THE PLUG.

Possible Cause	Isolation Procedure	Correction
(b) Defective ignition unit	Energize ignition unit with 115-volt, 400-cps current. Touch case and check for vibration. Listen for characteristic buzz or vibration to indicate good unit.	Remove and replace ignition unit per 74-2-1.

WARNING: UNDER NO CIRCUMSTANCES SHOULD THE HARNESS OR IGNITER BE HELD WHILE THE IGNITION SYSTEM IS ENERGIZED. VOLTAGE IS DANGEROUSLY HIGH, SOMETIMES REACHING A POTENTIAL OF 12000 VOLTS.

(c) Defective cable	Disconnect cable at both ends, and check for continuity or ground with a multimeter.	Replace defective cable.
(4) Defective aircraft or ground equipment power supply circuits.	Refer to starting trouble-shooting, 80-1-0.	
(5) Faulty fuel nozzle	Replace fuel nozzle in the correspondent ignition combustion liner. Attempt new start. Check fuel nozzle screen for contamination. If applicable, refer to fuel contamination trouble-shooting.	

E. Engine Fails To Start In Flight But Starts Satisfactorily On The Ground.

If an engine fails to start in flight but starts satisfactorily on the ground, remove and replace the ignition unit. Return the defective unit to overhaul for a complete check-out. Loss of hermetic sealing of units can cause improper operation at altitude.

F. Engine Will Not Accelerate To Idle Speed (or too much time to accelerate to idle speed).

NOTE: This suggests either not enough fuel to accelerate the engine or too much fuel which attempts to accelerate the engine too fast and causes the compressor to stall. In the case of low fuel flow, the engine will have relatively low EGT and very slow acceleration, usually hanging up in the 20 to 40% RPM range. If too much fuel, EGT is high throughout the acceleration, and the stall which began at low RPM, manifests itself just below idle speed as RPM hang up and in some cases an audible rumble.

Possible Cause	Isolation Procedure	Correction
(1) Specific gravity setting too high (low fuel flow), setting too low (high fuel flow)	Check specific gravity setting on the fuel control. Nominal setting is 0.77.	Set specific gravity between 0.72-0.85 to obtain optimum operation.

NOTE: The specific gravity setting affects starting characteristics and acceleration characteristics in both forward and reverse thrust. All three modes of engine operation should be considered when changing this setting.

(2) Leaking or damaged CDP sensing line of power reduction system	Check CDP line to fuel control for loose fitting or crack.	Repair leakage. If leakage occurs in the circumferential or radial limiter tubes in the fan frames, the engine has to be removed and tubes repaired or replaced.
(3) Aircraft bleed air valve is open	Check bleed air valve for operation.	Replace bleed air valve per 36-1-1.
(4) Fuel system contamination	Refer to Fuel Contamination, paragraph 11.	
(5) Variable stators not closed	Check variable stator actuator closed stop positions per 73-1-8.	Correct actuator stops per 73-1-8.
(6) Faulty fuel control	Other possible causes eliminated.	Replace fuel control per 73-1-4.

G. Engine Overtemperature During Start (fuel flow normal).

NOTE: When starting time is long, the natural accumulation of fuel may produce a hot start. If another start using the alternate ignition circuit is normal, check the main ignition circuit for a marginal igniter plug. Refer to paragraph D. If a purge run was made immediately before the hot start, perhaps drain time was insufficient, the combustion section drain is blocked or the pressurizing and drain valve failed to drain.

Possible Cause	Isolation Procedure	Correction
(1) EGT indicating system	Refer to Faulty Indication Problems, paragraph 9.	
(2) Fuel trapped in **combustion or turbine sections**	Check engine drain for blockage.	Clear blocked drains. Allow sufficient drain **time.**
(3) P&D valve defective	Replace P&D valve.	Replace P&D valve per 73-1-6.

NOTE: A hot start can be caused by an undetected stall or hang up during acceleration to idle. Refer to paragraph I for trouble-shooting.

H. Engine Overtemperature During Start (fuel flow above normal).

Possible Cause	Isolation Procedure	Correction
(1) Faulty CIT **sensor**	Remove and inspect CIT sensor capillary tubes for leakage (discoloration of the tube is a good indication of leakage). Check variable vane schedule and plot curve, per Adjustment/ Test, 72-0. (a) If parallel to **schedule, but above** or below by more **than tolerance, sensor is faulty.** (b) If curves tend to intersect so that the **schedule exceeds** tracking check tolerance, **and cannot be** corrected by a rigging change, the fuel control is faulty **-or-** Check the CIT sensor per Adjustment/Test, 73-1-5.	Replace CIT sensor per 73-1-5.

Possible Cau'se	Isolation Procedure	Correction
(2) Faulty fuel control	All other possible causes eliminated.	Replace fuel control per 73-1-4.

I. Engine Has Acceleration Hang-Up and/or Stall During Start (with possible overtemperature).

Possible Cause	Isolation Procedure	Correction
(1) Restricted engine inlet	Check inlet	Remove restriction.
(2) Foreign object damage to rotors	Check compressor and turbine rotor for damage.	Replace engine if rotors are damaged.
(3) Leaking or damaged CDP line or power reduction system	Check CDP lines for loose fitting or cracks.	Repair leakage. If leakage occurs in the circumferential or radial limiter tubes in the fan frames, the engine has to be removed and tubes repaired or replaced.
(4) Feedback cable sticking or binding or VSRM defective	Disconnect feedback cable at the bellcrank and pull cable back and forth approximately one inch. Cable should move freely. Inspect VSRM.	Relieve cable bind and lubricate with DC33 or equivalent, or replace cable/conduit per 73-1-9. Replace VSRM per 73-1-10.

CAUTION: CABLE IS SPRING LOADED. 00 NOT ALLOW CABLE TO SNAP BACK. DUE TO SPRING TENSION, INTERNAL DAMAGE MAY RESULT.

(5) Faulty CIT sensor	Remove and inspect CIT sensor capillary tubes for leakage (discoloration of the tube is a good indication of leakage). Check variable vane schedule and plot curve per Adjustment/Test, 72-0.	Replace CIT sensor per 73-1-5.

Possible Cau·se	Isolation Procedure	Correction
	(a) If parallel to schedule, but above or below by more than tolerance, sensor is faulty.	
	(b) If curves tend to intersect so that the schedule exceed tracking check tolerance, and cannot be corrected by a rigging change, the fuel control is faulty. -or- Check the CIT sensor per Adjustment/Test, 73-1-5.	
(6) Faulty fuel control	Check variable vane schedule per Adjustment Test, 72-0. If curves tend to intersect so that the schedule exceeds tracking check tolerance and cannot be corrected by a rigging change, the fuel control is f au'lt y.:	Replace fuel control per 73-1-4.
(7) First stage turbine nozzle area too small	other possible causes eliminated.	Replace engine.

NOTE: A small first stage turbine nozzle area, while good for performance, reduces stall margin. Engines with dirty compressors have the stall margin decreased. Compressor washing should be performed per ASIL 21B in an attempt to improve stall margin before a decision to replace the engine is made.

3. Idle Problems

A. Idle Speed Is Out Of Limits.

NOTE: A slight RPM shift is not a symptom of a defective component as long as the correct setting is still within the adjustment range. Adjust the speed setting on the fuel control per 73-1-4. If no amount of adjustment can bring RPM within limits, proceed with the troubleshooting.

Possible Cause	Isolation Procedure	Correction
(1) Engine torque box out of rigging	Refer to engine controls troubleshooting 76-1-0.	
(2) Leaking or damaged CDP line or power **reduction system** (if idle speed is below limits)	Check lines for loose fittings or cracks.	Repair leakage. If leakage occurs **in the circumfer**ential or radial **limiter tubes, remove the engine** and replace defective tube.
(3) Faulty fuel **control**	All other possible **causes eliminated.**	Replace fuel control per 73-1-4.

B. Engine Surges Or Rumbles At Idle

Possible Cause	**Isolation Procedure**	**Correction**
(1) Foreign object damage to rotors	Check rotor for damage.	Replace engine.
(2) Pressurizing and **drain valve is** fluttering	With the engine at idle speed, bleed the refer**ence pressure line be**tween the P&D valve and the fuel control. If the P&D valve is fluttering, a pulsating leakage will be observed.	Replace P&D valve per 73-1-6.
(3) Variable vaneS are oscillating due to sticking feedback cable	**Monitor vane angle** stability by observing **lever arms.**	**Remove and inspect.**

Possible Cause	Isolation Procedure	Correction
(4) Faulty fuel control	If none of the above items are malfunctioning, suspect fuel control.	Replace fuel control per 73-1-4.
(5) Fuel system contamination	Refer to Fuel Contamination, paragraph 11.	

4. Performance Problems

A. Engine Unable To Reach Selected Speed - All Engine Parameters Are Low.

Possible Cause	Isolation Procedure	Correction
(1) Fuel control shaft out of position	Check fuel control shaft travel by positioning aircraft take-off stop and check control shaft for proper position.	Rig aircraft throttle system per engine controls 76-1-0.
(2) Hot shift		Replace CIT sensor.
(3) Leakage at CDP line or power reduction system	Check lines for leakage.	Repair leakage.
(4) Aircraft bleed air system defective (high EGT)	Inspect aircraft bleed air system for evidence of leaks.	Refer to air system 75-0.

B. Engine Speed Is Out Of Limits - All Other Engine Parameters Are Normal.

Possible Cause	Isolation Procedure	Correction
(1) Faulty indicator	Interchange indicators with other engine.	Replace indicator.
(2) Defective tachometer generator		Replace tachometer generator per 77-21-1.
(3) Engine maximum speed improperly set	Check maximum speed adjustment in the fuel control.	Adjust maximum speed per 73-1-4.

Possible Cause	Isolation Procedure	Correction
(4) Defective wiring **or loose terminal connections**	Check continuity between: **terminals of generator and ground, generator to indicator, indicator and** ground.	Repair and/or replace **wiring as required.**
(5) Faulty fuel control	All other possible causes eliminated.	Replace fuel control per 73-1-4.

C. Fan Speed Is Out Of Limits - All Other Engine Parameters Are Normal.

Possible Cause	**Isolation Procedure**	**Correction**
(1) Fan inlet duct blocked	Visually check fan inlet.	Clear inlet of **obstruction.**
(2) Fan blade damage	Inspect fan blades.	Replace engine.
(3) Faulty indicator	Interchange indicator with other engine.	Replace indicator **per aircraft instructions.**
(4) Fan tachometer generator defective		Replace tachometer **generator per** 77-21-2.
(5) Loose or broken **wire between** (a) tachometer and ground (b) tachometer **generator and indicator** (c) indicator and ground	Check for continuity.	**Repair or replace wire as required.**
(6) Short in wire in **electrical circuit of fan rear frame**	Check continuity at outer end of electrical strut.	Replace cable inside of tail **cone.**

Possible Calise	Isolation Procedure	Correction
(7) Primary exhaust nozzle cone out of original position	Measure nozzle slant-height per aircraft instructions and compare with recorded valves stamped on plate situated at left side of compressor front frame. Values should coincide.	Adjust exhaust nozzle cone to original position per aircraft instructions.

CAUTION: THE NOZZLE SLANT-HEIGHT ASSIGNED TO THE ENGINE HAS BEEN OBTAINED IN THE TEST CELL TO PROVIDE THE BEST THRUST/EPR CORRELATION AND EPR/FAN SPEED RELATIONSHIP. UNDER NO CIRCUMSTANCES SHOULD THE SLANT-HEIGHT BE READJUSTED TO IMPROVE EPR INDICATION ON MARGINAL PERFORMANCE ENGINES SINCE THRUST/EPR CORRELATION WOULD BE DISRUPTED.

D. EPR On Engine Is Low - All Other Parameters Are Normal.

NOTE: Low EPR is normally a flight-logged problem and may have different meanings depending many times upon the pilot's point of view. The troubleshooter should try to obtain all available data before isolating the fault to an engine system. Define if the problem is manifested at cruise or take-off. Engine's throttle is set by fuel flow at cruise and by EPR at take-off. An actual low EPR engine will consistently show reports of "low EPR at cruise" and "high EGT at take-off." At cruise, the aircraft will show slight "tendencies" that require corrections. The problem is sometimes reported as "throttle misalignment." Since the engines may show some differences in fuel flow due to individual engine characteristics and stack-up conditions, define the problem as low EPR when high EGT is present at take-off.

Possible Cause	Isolation Procedure	Correction
(1) Faulty EPR indicator	Interchange indicators.	Refer to 77-12-0.
(2) PT7 probe bent or twisted	Inspect visually.	Replace PT7 probe per 77-21-4.
(3) Clogged PT7 probe or strut tube	Check probe visually. Check strut tube by blowing air through it.	Replace or clean probe. Clean strut tube.
(4) Clogged PT2 line	Check PT2 line for obstruction.	Clean PT2 line.

Possible Cause	Isolation Procedure	Correction
(5) PT_7 or PT2 line leaking	Check lines for cracks or loose fittings. Pressure check for leaks.	**Repair or replace lines.**
(6) Faulty EPR transmitter		Replace EPR transmitter per 77-12-1.
(7) Variable stators out of rigging	Check variable stators running rig per Adjustment/Test, 72-0.	Correct rigging.

E. High EGT - All Other Parameters Low or Normal At All Points. (See paragraph D, troubleshoot EPR indication system. The EPR may be reading low, not EGT reading high.)

Possible Cause	Isolation Procedure	Correction
(1) Foreign object damage to rotors	Check compressor and turbine for damage. Remove No. 7 fuel nozzle and use borescope to inspect rear stage of compressor rotor.	Replace engine.

CAUTION: THE DECISION TO CHECK OPERATE AN ENGINE WITH SUSPECTED, BUT NOT CONFIRMED FOD, MUST BE CAREFULLY CONSIDERED. SUCH A PROCEDURE SHOULD BE TERMINATED IF RPM HANG UP, HIGH EGT, OR ENGINE RUMBLE IS EVIDENT DURING STARTING, OR IF ACCELERATION OR VIBRATION CHARACTERISTICS ARE ABNORMAL.

(2) Faulty EGT indication		
(a) EGT indicator defective	Interchange indicator with other engine and check.	Replace indicator.
(b) Shorted thermocouple	Check thermocouples in each harness by checking each pin in the connector to ground; resistance should be 1000 ohms minimum.	Replace defective thermocouple harness per 77-21-3.
(c) Thermocouple opening during operation	Refer to Adjustment/Test, 77-21-3.	Remove engine and replace defective harness.

Possible Cause	Isolation Procedure	Correction
(3) Combustion section damaged or "hot streak"	Inspect combustion casing for bulges caused by hot spots. Inspect turbine stator casing for hot spots. Inspect fuel nozzle screens for contamination. Refer to Fuel Contamination, paragraph 11.	Replace engine if combustion casing shows bulging. Refer to trouble-shooting Fuel Contamination, paragraph 11.
(4) Variable stators out of rigging	Check variable stators running rig per Adjustment/Test, 72-0.	Correct rigging.

F. High EGT - High Fuel Flow - All Other Parameters Low or Normal At All Points.

Possible Cause	Isolation Procedure	Correction
(1) Foreign object damage to rotors	Check compressor and turbine for damage. Remove No. 7 fuel nozzle and use borescope to inspect rear stage of compressor rotor.	Replace engine.

CAUTION: THE DECISION TO CHECK OPERATE AN ENGINE WITH SUSPECTED, BUT NOT CONFIRMED FOD, MUST BE CAREFULLY CONSIDERED. SUCH A PROCEDURE SHOULD BE TERMINATED IF RPM HANG UP, HIGH EGT, OR ENGINE RUMBLE IS EVIDENT DURING STARTING, OR IF ACCELERATION OR VIBRATION CHARACTERISTICS ARE ABNORMAL.

(2) Defective bleed air system	Check bleed air system per Air System, 75-0.	
(3) Faulty CIT sensor	Check variable vane schedule and plot curve per Adjustment/Test 72-0.	Replace CIT sensor per 73-1-5.
	(a) If parallel to schedule, but above or below by more than tolerance, sensor is faUlty.	

Possible Cause	Isolation Procedure	Correction
	(b) If curves tend to intersect so that the schedule exceeds tracking check tolerance, and cannot be corrected by a rigging change, the fuel control is faulty **-or-** Check the CIT sensor per Adjustment/Test, 73-1-5.	
(4) Faulty fuel control	Check variable vane schedule per Adjustment/ Test, 72-0. If curves tend to intersect so that the schedule exceeds tracking check tolerance **and cannot be corrected** by a rigging change, the fuel control is faulty.	Replace fuel control per 73-1-4.
(5) Faulty basic engine	All other possible causes eliminated.	Replace engine. Investigate engine performance in a test cell.

5. Operational Problems

A. Slow Engine Acceleration From Idle To Take-Off Power.

Possible Cause	Isolation Procedure	Correction
(1) Foreign object damage to rotors	Check"compressor and fan rotor for damage.	Replace engine.
(2) Aircraft bleed air system	Check the bleed air system for leakage by making accelerations with bleed air on and off. Check for large increase in acceleration with bleed air off.	Refer to Air System, 75-0.

Possible Calise	Isolation Procedure	Correction
(3) Leaking or damaged CDP line or power reduction system	Check lines for loose fittings or cracks.	Repair leakage. If leakage occurs in the circumferential or radial limiter tubes in the fan frames, the engine has to be removed and tubes repaired or replaced.
(4) Specific gravity setting too high (low fuel flow); setting too low (high fuel flow)	Check specific gravity setting on the fuel control. Nominal setting is 0.77.	Adjust specific gravity setting between 0.72 and 0.85 to obtain optimum operation.

NOTE: The specific gravity setting affects starting characteristics and acceleration characteristics in both forward and reverse thrust. All three modes of engine operation should be considered when changing this setting.

(5) Faulty fuel control	Other possible causes eliminated.	Replace fuel control per 73-1-4.

B. Overtemperature Or Stall Occurs During Engine Acceleration.

Possible Cause	Isolation Procedure	Correction
(1) Foreign object damage to rotors	Check compressor and turbine rotors for damage. Remove No. 7 fuel nozzle and use borescope to inspect rear stage of compressor rotor.	Replace engine.

CAUTION: THE DECISION TO CHECK OPERATE AN ENGINE WITH SUSPECTED, BUT NOT CONFIRMED FOD, MUST BE CAREFULLY CONSIDERED. SUCH A PROCEDURE SHOULD BE TERMINATED IF RPM HANG UP, HIGH EGT, OR ENGINE RUMBLE IS EVIDENT DURING STARTING, OR IF ACCELERATION OR VIBRATION CHARACTERISTICS ARE ABNORMAL.

Possible Cause	Isolation Procedure	Correction
(2) Feedback cable sticking or binding, or VSRM defective	Disconnect feedback cable at the bellcrank and pull cable back and forth approximately one inch. Cable should move freely. Inspect VSRM **for malfunctioning.**	Relieve cable bind **and lubricate, or** replace cable/ conduit per 73-1-9. Replace VSRM per 73-1-10.

CAUTION: CABLE IS SPRING LOADED. DO NOT ALLOW CABLE TO SNAP BACK.

(3) Faulty CIT sensor	Check variable vane schedule and plot curve per Adjustment/Test, 72-0. (a) If parallel to schedule but above or below **by more than tolerance, sensor is faulty.** (b) If curves tend to intersect so that the **schedule exceeds tracking check tolerance, and cannot be corrected by** a rigging change, the fuel control is faulty. **-or-** Check the CIT sensor per Adjustment/Test, 73-1-5.	Replace CIT sensor per 73-1-5.
(4) Faulty fuel control	Check variable vane schedule per Adjustment/ Test, 72-0. If curves tend to intersect so that the schedule exceeds tracking check tolerance, and cannot be corrected by a rigging change, the fuel control is faulty.	Replace fuel control per 73-1-4.

C. Engine Surge Or Rumble Occurs At Conditions Other Than Idle.

(1) Variable vanes are oscillating due to sticking feedback cable or VSRM defective	Monitor vane stability by observing lever arms. Inspect VSRM for malfunctioning.	Remove and insert. Lubricate or replace. Replace VSRM per 73-1-10.

Possible Cause	Isolation Procedure	Correction
(2) Foreign object damage to rotors	**Check compressor and turbine rotors for** damage.	Replace engine.
(3) Variable stators **are too open**	Check variable stators running rig per Adjustment/Test, 72-0.	Correct rigging.
(4) P&D valve fluttering (if rumble occurs below 80% RPM)		Replace P&D valve per 73-1-6.
(5) Fuel system con**tamination**	Refer to Fuel Contamination, paragraph 11.	Refer to Fuel Con**tamination, para**graph **n.**
(6) Faulty fuel control	All other possible **causes eliminated.**	Replace fuel control per 73-1-4.

D. Stall Occurs During Engine Deceleration.

Possible Cause	Isolation Procedure	Correction
(1) Foreign object damage to rotors	**Check compressor and turbine rotors for** damage.	Replace engine.
(2) Variable stators have schedule shift **in open direction**	Check variable stators **static and running rig** per Adjustment/Test, 72-0.	Correct rigging.
(3) Faulty CIT sensor (cold shift)	**Check variable vane** schedule and plot curve per Adjustment/Test, 72-0.	Replace CIT sensor per 73-1-5.
	(a) If parallel to sched**ule, but above or** below by more than **tolerance, sensor** is faulty.	

Possible Cause	Isolation Procedure	Correction
	(b) If curves tend to intersect so that the schedule exceeds tracking check tolerance, and cannot be corrected by a rigging change, the fuel control is faulty -or- Check the CIT sensor per Adjustment/Test, 73-1-5.	
(4) Faulty fuel control	Check variable vane schedule per Adjustment/ Test, 72-0. If curves tend to intersect so that the schedule exceeds tracking check tolerance, and cannot be corrected by a rigging change, the fuel control is faulty.	Replace fuel control per 73-1-4.
(5) Feedback cable sticking or binding or VSRM defective	Disconnect feedback cable at the bellcrank and pull cable back and forth approximately one inch. Cable should move freely. Inspect VSRM.	Relieve cable bind and lubricate with DC33 or equivalent, or replace cable/ conduit per 73-1-9. Replace VSRM per 73-1-1.

CAUTION: CABLE IS SPRING LOADED. DO NOT ALLOW CABLE TO SNAP BACK.

E. Engine Flames Out.

Possible Cause	Isolation Procedure	Correction
(1) Contaminated fuel	Refer to Fuel Contamination, paragraph 11.	Refer to Fuel Contamination, paragraph n.
(2) Foreign object damage to rotors or non-rotating accessory drives or gear train	Pump variable stators open and check compressor for FOD. Rotate compressor and check accessories for rotation. Remove No. 7 fuel nozzle to inspect rear stage of compressor rotor.	Replace engine. If an accessory drive is found defective, replace the accessory drive, drain and flush oil system, and replace all oil filters.

Possible Cause	Isolation Procedure	Correction
(3) Faulty fuel pump	Check if fuel pump shaft is sheared off. Verify if engine fuel pump low pressure light comes on.	Replace fuel pump per 73-1-1.
(4) Lean fuel flow	Check rigging to fuel control fuel shut-off shaft.	Correct rigging per 76-1-0.
	Check specific gravity setting.	Readjust.
	Check fuel lines for obstructions.	Remove obstructions.
(5) Incorrect variable stator rigging	Disconnect feedback cable at the bellcrank and pull cable for approximately one inch. Cable should move freely.	Lubricate or replace cable/conduit per 73-1-9.
	Inspect VSRM for malfunctioning.	Replace VSRM per 73-1-10.
	Check variable stator rigging per Adjustment/ Test, 72-0.	Correct rigging.
(6) Faulty fuel control	All other possible causes eliminated.	Replace fuel control per 73-1-4.

F. Excessive Vibration.

NOTE: Vibration indications from the pickups are generally due to unbalance in the engine rotating masses. There are, however, other characteristic modes of operation which may produce higher than normal vibration levels. While none of these conditions are desirable, it can be seen that only the condition described in (d) is true vibration and rejection of an engine for the other type discrepancies could cost considerable time and effort to be needlessly expended. After determining that excessive vibs are not of the (a), (b) or (c) type, it is also wise to switch vibration meters and then pickups to eliminate instrumentation from the picture before rejecting the engine.

(a) Most common among these is the idle vibs experienced upon restarting the engine after a 20 to 30 minute shutdown. This is due to rotor bow caused by the heat gradient from the bottom to the top of the engine and disappears after a few **minutes of running, especially at above idle power. Restarts** within 20 minutes or after 30 minutes after shutdown are less likely to produce idle vibs.

(b) Idle rumble, a fuel and combustion system instability, often produces higher than normal vibs. These are usually of about 22 cps frequency and can be isolated from engine rotating parts by a frequency meter. Again, operation above idle **power for a short period of time will sometimes clear this problem. The most common cure for this problem is replace**ment of the P&D valve.

(c) Engine stalls will also produce mild to violent vib levels, usually accompanied by audible reports.

(d) The natural frequency of the main engine occurs between 80 and 85% engine RPM, thus there is a tendency to see peak vibration levels in this area. The RPM at which this peak occurs varies slightly with compressor 17th stage seal leak**age pressure level.**

Possible Cause	**Isolation Procedure**	**Correction**
(1) Loose vibration pickups and brackets	Check security of pick-ups and brackets.	Tighten pickups and brackets.
(2) Loose or damaged leads	Check leads for security and damage.	Replace damaged leads.
(3) Loose engine **mounts**	**Check security of mounts.**	Tighten mountings. **Refer to Power** Plant - General, 71-0.
(4) Foreign object **damage to rotors**	Pump variable stators **open and check com**pressor for FOD. Inspect fan blades for damage **and fan frames for ex-cessive cracking. Re-move *No.* 7 fuel nozzle to inspect rear stage of compressor rotor.** Rotate the engine by hand and listen for **unusual noises.**	**Replace engine.**

Possible Cause	Isolation Procedure	Correction
(5) Main engine **bearings or accessory drives** damage	Rotate engine by hand **and listen for unusual** noises. Refer to Ab**normal Engine Noises,** paragraph 6.	Replace engine.
	Check magnetic plugs at gearboxes. Check oil filters.	Replace engine if **metal chips are** found.
(6) Faulty CSD	Disconnect and check CSD. Check splines at gearbox.	Replace CSD per 24-1-1.
(7) Faulty hydraulic pump	Disconnect the hydraulic pump. Check splines at gearbox.	Replace hydraulic pump.
(8) Loose or damaged **engine air ducts**	Check air ducts for **security and damage.**	Refer to Nacelles Chapter 54.
(9) Loose or damaged **thrust reverser** linkage	Check thrust reverser for security and damage.	Refer to Exhaust Chapter 78.
(10) Other reasons		**Replace engine.**

NOTE: When the vibration condition cannot be corrected, record engine RPM where condition exists and corresponding vibration indication level for guide to corrective action required at repair level maintenance.

6. Abnormal Engine Noise

A. Engine Noisy During Shutdown.

NOTE: Jet engines, as any other type engine, have noises that are peculiar to this type engine. Only experience with the engine will **make the normal noises a familiar sound so that the abnormal** noises can be distinguished. Turn rotors by hand to determine the amount of drag associated with the noise. Determine the ap**proximate location of the noise, i.e., gearbox, compressor, turbine, fan.**

WARNING: WHEN ROTATING ROTORS BY HAND, TAKE PRECAUTIONS TO PREVENT HAND BEING CAUGIIT BETWEEN ROTATING AND STATIONARY PARTS.

Possible Cause	Isolation Procedure	Correction
(1) Normal air seals and turbine shroud rubs	Scraping noises are sometimes associated with newly overhauled or repaired engines and usually associated with "wearing in" of new seals. It can be distinguished by the continuity of sound. A continuous, uninterrupted noise. No rotor rolled-back evidenced after coastdown.	This condition may be evidenced on new or newly overhauled engines but will clear after wear-in.
(2) Defective turbine shroud	Listen at turbine stator casing for noise. Sound will be noted as each bucket hits shroud, therefore an interrupted, bearing noise will be emitted. Coastdown of rotor will be jerky.	Replace engine.
(3) Defective fan shroud	Listen at fan frames for noise. Characteristic noise will be similar to item (2).	Replace fan component.
(4) Main engine bearing rough	Listen at main bearing areas. Noise frequency will correspond to engine RPM and be of a thumping nature. Coastdown will be less than normal. Examine filters for metal contamination.	Replace engine.

B. Operational Noises.

NOTE: Abnormal engine operation can result from fuel or combustion system instability, vibration of the engine structures and noise internal to the engine or accessories due to interference or foreign object damage.

Possible Cause	Isolation Procedure	Correction
(1) Foreign object damage to rotors	Pump variable stators open and check compressor for FOD. Inspect fan blades for damage. Remove No. 7 fuel nozzle to inspect rear stage of compressor rotor.	Replace engine.
(2) Fuel or combustion system defective	Instability within either system is heard as a rumble. Refer to Engine Surges and Rumbles At Idle, paragrapb 3.B.	
(3) Vibrating casing structures	Refer to Excessive Vibration, paragraph 5.F.	
(4) Interference noise	Refer to paragraph A.	

7. Oil Problems

NOTE: A malfunction within the lube system is usually quite obvious. , Either the cockpit pressure indicator will display an abnormal reading or visual observation will establish the need for corrective action. The lubrication system is not complex, so little trouble may be anticipated in operation or service by the engine mechanic. Beyond obvious leaks, the oil pressure and temperature indicators in the cockpit provide the first symptoms of a system malfunction. Readings other than normal suggest the nature of malfunction, but they cannot isolate the cause. Various troubles may create similar indications; however, experience and forethought will indicate the most probable causes.

(a) Oil pressure, displayed on the cockpit indicator, is the pressure differential between the lube system and the sump pressurizing system. A transducer, located downstream from the lube oil filter, **forms an electric signal proportional to oil pressure. This signal is modified by a second signal from a sump pressurizing line trans**ducer, and is also applied to the cockpit indicator. Both trans**ducers and the connecting circuitry are supplied by the airframe manufacturer, but they are included in the engine lube system** troubleshooting gUide.

(b) Oil temperature, indicated on the cockpit oil temperature indica**tor, is scavenge oil temperature. The sensor is inserted into the oil stream at the scavenge oil filter, thus presenting an accurate indication of the maximum temperature of the circulating oil.**

(c) The oil filters will normally provide a reliable clue to a lube **system failure. Oil contamination of some sort, either as a cause** or result of the malfunction, is usually evidenced in the filters. The filters.should be checked whenever an abnormal symptom occurs.

CAUTION: OPERATING THE ENGINE TO LOCALIZE A LUBE SYSTEM MALFUNCTION SHOULD BE AVOIDED IF POSSIBLE. A RUN-UP WITH A LUBRICATION DEFICIENCY COULD RESULT IN UNNECESSARILY DAMAGING BASIC ENGINE COMPONENTS. CAREFUL INSPECTION AND EVALUATION WILL USUALLY REVEAL THE TROUBLE, SO OPERATING THE ENGINE IS NOT REQUIRED. HOWEVER, SHOULD IT BE NECESSARY TO RUN THE ENGINE, FIRST MOTOR THE ENGINE WITHOUT IGNITION, USING THE AIR STARTER. BE CERTAIN THAT THE TANK CONTAINS ADEQUATE OIL TO SUPPLY THE SYSTEM.

A. No Oil Pressure Indication (During Engine Start).

Possible Cause	Isolation Procedure	Correction
(1) Indicating **system** defective	**See oil pressure indi**cating system trouble-shooting, 77-6-0.	
(2) Oil supply deficient	Check oil level in supply tank.	Replenish oil supply.
(3) Lube hose collapsed	Check hose between tank and pump by disconnecting at pump and checking flow.	Replace hose if damaged.
(4) Lube pump in**operative**	Check lube pump outlet.	Replace pump **if defective.**

B. High Oil Pressure (During Engine Start).

NOTE: Extreme low temperature may cause abnormally high oil pressure indication (up to 200 psi) during start. Pressure should drop to normal after engine reaches idle speed. This procedure is **to cover cases where pressure exceeds the 200 psi maximum.**

Possible Cause	Isolation Procedure	**Correction**
(1) Check valve in bypass **line** re-**versed**	Check position of check valve. **It** should permit bypass flow.	**Reverse check valve.**
(2) Check valve in bypass **line** will **not open**	**Remove check valve and** check operation.	Replace check **valves.**
(3) Collapsed line in bypass **circuit**	Remove line and check.	Replace.
(4) Defective indicating system	**Refer to oil pressure** indicating system troubleshooting, 77-6-0.	

C. Low Oil Pressure (During Engine Operation).

Possible Cause	**Isolation Procedure**	**Correction**
(1) Defective indicating system	**Refer to oil pressure indicating system** troubleshooting, 77-6-0.	
(2) Oil supply **deficient**	Check oil level in supply tank.	Replenish oil supply.
(3) Defective lube pump	Check lube pump outlet.	Replace pump per 72-5-2.
(4) External leaks	Inspect/check all visible piping and engine **accessories.**	Change defective **piping or component.**

D. High Oil Pressure (During Engine Operation).

Possible Cause	Isolation Procedure	Correction
(1) Defective indicating system	Refer to oil pressure indicating system troubleshooting, 77-6-0.	
(2) Clogged oil jet	Check filter for contamination. Filter may give clue to what has clogged jet.	Pump vacuum on each of the main oil inlets to the main engine bearings to remove foreign material. If this does not remedy the malfunction, replace gearbox or engine.

E. Oil Temperature Rise.

Possible Cause	Isolation Procedure	Correction
(1) Defective indicating system	Refer to oil temperature indicating system, 77-5-0.	
(2) Fuel-oil cooler defective	Check oil temperature "in" and "out" of cooler.	Replace cooler per 72-5-7.

F. Fluctuating Oil Pressure.

Possible Cause	Isolation Procedure	Correction
(1) Low oil in tank	Check oil level in supply tank.	Replenish oil supply.
(2) Defective pressure transmitter or indicator		Replace defective transmitter or indicator per 77-5-0.
(3) Contaminated or weak check valve spring in the oil supply filter	Inspect filter and valve for contamination.	Replace check valve.
(4) Defective lube pump		Replace lube pump per 72-5-2.

G. Fuel Mixed With Lube Oil.

Possible Cause	Isolation Procedure	Correction
(1) Ruptured oil cooler		Replace oil cooler per 72-5-7. Drain and flush lube system.

H. High Oil Consumption.

Possible Cause	Isolation Procedure	Correction
(1) External leaks	Inspect all external oil lines, fittings, gearbox and accessories joints for leaks. Motor or run the engine at idle with the pod doors open and watch for leaks.	Correct leakage by replacing defective piping, gasket, etc.
(2) Scavenge pump defective	Check for leakage from the bearing sumps. Check for sign of leaks from: IGV support at compressor front, frame, 17th stage leakage seal struts, Fan rotor, Exhaust cone.	Replace defective pump. Determine cause of pump failure. Pumps without screen at inlet port can be damaged by foreign objects from gearbox. Check magnetic plug at gearbox and scavenge and supply oil filters. If contaminated, replace gearbox and flush lube system if problem is confined to the gearbox, otherwise, replace the engine for suspected bearing failure.
(3) Faulty anti-static leak check valve allowing oil to drain into sumps and gearbox after engine shutdown	Remove check valve and check for sticking in open position (valve is located in the outlet port of the lube supply filter).	Replace valve.

Possible Cause	Isolation Procedure	Correction
(4) Oil foaming	Check oil for contaminants.	Change engine oil.
(5) Sump pressure above normal	Check sump manifold pressure. At idle, speed should be -8 to -3 in. Hg. At 85%, should be within -8 to zero in. Hg.	If pressure is above normal troubleshoot pressurizing system (see paragraph *J).*

I. Increase In Oil Quantity (With No Increase In CSD Level).

Possible Cause	Isolation Procedure	Correction
(1) Defective fuel oil cooler	Take sample of oil and check for fuel.	Change oil cooler per 72-5-7.

J. Sump Pressure Above Normal.

Possible Cause	Isolation Procedure	Correction
(1) Leaking sump vent lines	Check fitting and lines for leaks.	Tighten or replace lines.
(2) Sump and tank pressurizing valve defective	Check sump vent section of the valve by blowing in the port that connects to the sump vent manifold. If passage is open, valve is defective.	Replace valve per 72-5-9.
	Check tank vent section of the valve by closing off the sump vent port and blowing into the overboard vent port. If passage is open, valve is defective.	Replace valve per 72-5-9.
(3) Sump vent check valve defective	Remove and inspect check valve.	Replace valve.
(4) Individual sump or carbon seal defective	Take individual sump readings per steps (a) through (e).	Replace engine.

(a) Check individual sump effect on sump manifold pressure by disconnecting each of the main sump areas, one at a time, from the manifold and reading the manifold pressure. The effect the individual sump has on the total reading can give an indication of a defective sump area.

1 Disconnect the sump vent line that connects the transfer gearbox to the sump vent manifold at the manifold. Cap the manifold connection, (leaving gearbox line open to atmosphere), operate engine and check manifold pressure reading. If manifold reading falls within limits make Isolated No.1 Bearing Sump and Gearbox Check.

NOTE: This check eliminates the effect of No. 1 bearing sump and gearboxes on the manifold pressure.

2 Disconnect the sump vent line that connects the compressor rear frame to the manifold at the manifold. Cap off the manifold (leaving the compressor rear line open to atmosphere), operate the engine and check the manifold pressure reading. If manifold reading falls within limits make Isolated No.2 Bearing Sump Check.

3 Disconnect the sump vent connection between the fan front frame and the manifold by disconnecting the lines from the tee connection at No. 2 strut of the fan front frame and putting a jumper line between the two lines. Operate the engine and check the manifold pressure reading. If manifold reading falls within limits, make Isolated No.3 and 4 Bearing Sump Check.

4 Disconnect the sump vent line that connects the fan rear frame to the manifold at the rear fitting of the tee connection at No. 2 strut of the fan front frame and cap the tee connection. Operate the engine and check the manifold pressure reading. If manifold reading falls within limits, make isolated No. 5 Bearing Sump Check.

(b) Isolated No. 1 Bearing Sump and Gearbox Check

1 Disconnect the sump vent line that connects the No.2, 3, 4 and 5 bearing sumps to the sump vent manifold at the manifold. Cap off manifold (leave lines open to atmosphere).

NOTE: The gearbox seal will leak if subjected to a high vacuum condition. Therefore the sump vent valve is left in the system by using the above method.

2 Connect a manometer to the manifold.

3 Operate the engine and read the manometer at IDLE and 96.5% rpm power setting.

4 The manometer reading should be less than a negative 4 inches of Hg. for both power settings, if not, continue procedure to **determine if problem is in front frame or gearboxes.**

5 Block the overboard vent of the sump pressurizing valve, a little at a time, until the manifold pressure gets up to PLUS 5 inches of Hg. Hold this pressure for five minutes.

6 Check the gearbox casings and accessory seal drain for leakage. If leakage is evident, the problem is in the gearbox area, if **no leakage, the problem is in the front frame sump area.**

(c) Isolated No. 2 Bearing Sump Check

1 Disconnect sump vent line that connects compressor rear frame to the manifold at the manifold. Cap off the manifold.

2 Connect a manometer to the No. 2 bearing sump vent line.

3 Operate the engine at IDLE and 96.5% rpm power settings.

4 Check the manometer reading, it should be less than 0 inches of Hg. for both power settings.

(d) Isolated No. 3 and 4 Bearing Sump Check

1 Disconnect the sump vent lines from the tee connection at No.2 strut of the fan front frame.

2 Place a jumper line between the lines disconnected above.

3 Connect a manometer to one side and cap off the other side of **the tee connector.**

4 Operate the engine and read the manometer at IDLE and 96.5% rpm power settings.

5 Check the manometer readings, it should be negative 7 inches of Hg. or less at IDLE and 0 inches of Hg. or less at 96.5% rpm.

(e) Isolated No. 5 Bearing Sump Check

1 Disconnect the rear sump vent line from the tee connection at No. 2 strut of the fan front frame. Cap off the tee connector.

2 Connect a manometer to the No. 5 bearing sump vent lines.

3 Operate the engine and read manometer at IDLE and 96.5% rpm **power settings.**

4 The manometer reading should be plus 5 inches of Hg. or less at IDLE. At 96.5% rpm the following values are used:

No. 5 Sump +15 inches Hg or less

8. Anti-Icing Air Problems

A. Anti-Icing Air Systems Will Not Turn On.

Possible Cause	Isolation Procedure	**Correction**
(1) Dsfective anti-icing shut-off **valve**	Check power supply. If **it is normal, valve is** defective.	Replace valve per 75-21-1.
(2) Airframe electrical failure	**Refer to airframe electrical** trouble-shooting **procedure.**	**Follow airframe correction procedure.**

B. Anti-Icing Comes On When Switch Is OFF.

Possible Cause	Isolation Procedure	**Correction**
(1) Anti-icing shutoff valve stuck open	Run engine at 95% (cruise) speed with anti-icing turned off. Shut the engine down and feel the anti-icing manifold between the valve and front frame. If manifold is **hot, valve is defective;** if cold, manifold valve **is closed and is satis-**factory.	Replace valve per 75-21-1.

CAUTION: IF VALVE IS FOUND DEFECTIVE, PERFORM OVER-LIMIT INSPECTION OF ENGINE PER 72-0.

(2) Anti-icing shutoff **valve solenoid** shorted	When anti-icing system **is switched "ON" the aircraft circuit breakers** go out.	Replace valve per 75-21-1.
(3) Airframe electrical **circuit**	**Refer to aircraft maintenance manual**	Follow aircraft **maintenance manual corrective action.**

9. Faulty Indication Problems

NOTE: This section refers to problems which by their nature are obviously classified as faulty indioation system.

A. No Engine Speed Indication.

Possible Cause	Isolation Procedure	Correction
(1) Defective tachometer generator		Replace tachometer generator per 77-21-1.
(2) Defective engine speed indicator		Replace indicator per 77-1-0.
(3) Defective wiring or loose terminal connection	Check continuity between: terminals of generator and ground, generator and indicator, and indicator and ground.	Repair or replace as required.

B. Erratic Engine Speed Indications.

Possible Cause	Isolation Procedure	Correction
(1) Defective wiring or loose connections	Check continuity as outlined in paragraph *A.(3)*, while moving wires at terminals to detect faulty connections.	Repair or replace Wiring, or repair terminal connection as reqUired.
(2) Defective tachometer generator	Disconnect tachometer leads and check continuity of tachometer. Check between pins A and B, pin A to connector and pin B to connector. Resistance should not exceed 60 ohms.	Replace tachometer generator 77-21-1.
(3) Worn splines on tachometer generator or gearbox	Remove tachometer generator and inspect splines.	If spline wear is excessive, replace tachometer generator or gearbox as required.

C. No Fan Speed Indication.

Possible Cause	Isolation Procedure	Correction
(1) Defective indicator	Refer to Adjustment/ Test, 77-2-0.	**Replace indicator,** 77-2-0.
(2) **Loose or broken wire between:**	Check for continuity.	Repair or replace **wire as required.**
(a) tachometer gen- **erator** and ground		
(b) tachometer gen- **erator and** indi- **cator**		
(c) **indicator** and ground		
(3) Defective **tachometer** generator		Replace tachom- **eter generator** per 77-21-2.

D. Erratic Fan Speed Indication.

Possible Cause	**Isolation Procedure**	Correction
(1) Defective indicator	Refer to Adjustment/ Test, 77-2-0.	Replace indicator per 77-2-0.
(2) Defective wiring **or loose connections**	Check continuity between points given at C.(2), **while moving wires at** terminal to detect faulty **connections.**	**Repair or replace wiring, or terminal connections as required.**
(3) Defective tachometer **generator**		Replace tachom- **eter generator** per 77-21-2.
(4) Worn splines on **tachometer generator** or fan coupling shaft	**Remove tachometer gener-** ator and inspect splines.	**If spline wear is excessive, replace** tachometer gener- **ator or fan cou-** pling shaft as **required.**

E. No EGT Indication.

Possible Cause	Isolation Procedure	Correction
(1) Defective indicator		Replace indicator per 77-1-0.
(2) Broken thermocouple circuit (engine)	Disconnect and check the single lead (located in front of firewall) for continuity.	Replace lead per 77-3-0.
(3) Shorted thermocouple lead	Disconnect and check continuity of both solid and flexible lead.	Replace defective lead per 77-3-0.
(4) Shorted thermocouple	Check thermocouple in each harness by checking each pin in the connector to ground; resistance should be 1000 ohms minimum.	Remove engine and replace defective thermocouple harness per 77-3-0.
(5) Defective wiring between thermocouples and indicator	Disconnect electrical plug from indicator and check for continuity through wiring to thermocouples.	Repair or replace wires as required per 77-3-0.

CAUTION: 00 NOT CHECK CONTINUITY THROUGH INDICATOR. VOLTAGE FROM TESTER MAY DAMAGE TRANSISTORS AND DIODES IN INDICATOR.

F. Erratic EGT Indication.

Possible Cause	Isolation Procedure	Correction
(1) Loose wiring connections	Follow procedure outlined in Item E.(5). Move wiring at connection points while performing continuity check.	Repair or replace wires per 77-3-0.

G. Low Or No EPR Indication.

Possible Cause	Isolation Procedure	Correction
(1) Probe bent or twisted	Inspect visually.	Replace probe per 77-21-4.
(2) Clogged probe or strut tube	Check probe visually. Check strut by blowing air through it.	Replace or clean probe per 77-21-4. Clean strut tube.
(3) Cracked strut tube	Pressure check tube.	Replace engine or repair crack.
(4) Defective transmitter or indicator	Exchange indicators with other engine.	Replace indicator if defective per 77-13-0. Otherwise, replace transmitter per 77-13-1.
(5) Inlet line has obstruction	Check inlet line for obstruction or pinching.	Clean or replace line.
(6) Loose or broken wire in system	If no power through circUit, check for continuity through wiring.	Repair or replace wiring as required.
(7) Defective circuit breaker	Check for presence of power through PRESS RATIO INn circuit breaker corresponding to defective circuit.	

10. Thrust Reverser System

A. T/R doors remain in stowed position when thrust reverse control lever is placed in reverse thrust position "REVERSE THRUST" and "LATCH UNLOCK" lights do not illuminate.

Possible Cause	Isolation Procedure	Correction
(1) Defective circuit breaker	Check for presence of power through corresponding engine "REVERSE THRUST CONT" circuit breaker.	Replace circuit breaker.

Possible Cause	Isolation Procedure	Correction
(2) Defective interlock **valve solenoid**	Check for continuity through solenoid.	Replace interlock valve per 78-3-4.
(3) Defective interlock **valve control switch**	Check for continuity through each sWitch, with switch held in **closed position.**	Replace defective **switch.**
(4) Loose or broken **wire between:**	Check for continuity.	**Repair or replace wire as required.**
(a) reverse thrust latch cont circuit breaker and **interlock valve** control switch		
(b) interlock control switches and interlock **valve solenoid**		
(c) interlock valve **control switch** and ground.		
(5) Interlock valve **control switches** out of adjustment	Check switch adjustment in the pedestal cockpit.	Adjust per engine controls, 76-1-6.
(6) Low oil level in CSD/thrust reverser oil tank	Check oil level.	Replenish oil tank. **Determine cause of** low supply.
(7) Thrust reverse pump defective	Check pump output.	Replace defective pump per 78-3-1.
(8) Interlock valve defective	other possible causes **eliminated.**	Replace interlock valve per 78-3-4.

B. **Thrust reverser doors remain in stowed position when T/R control lever is** placed in reverse thrust position - "LATCH UNLOCK" light illuminates - "REVERSE THRUST" light does not illuminate.

Possible Cause	Isolation Procedure	Correction
(1) External leakage	Check system for leakage.	**Repair or replace** defective tubing.

Possible Cause	Isolation Procedure	Correction
(2) Latch actuator defective	Inspect actuator for broken shaft or leakage. Check slider gUide for proper functioning. Inspect stowing latch assembly for damage.	Replace latch **actuator per** 78-3-7. Replace stowing latch assembly per 78-1.
(3) Thrust reverser pilot (selector) valve out of rigging or defective	Check rigging per Engine Controls, 76-1-0.	Adjust rigging and/or replace valve.

C. "LATCH UNLOCK" Light Flicks During Flight.

Possible Cause	Isolation Procedure	Correction
(1) Loose connection	Check for continuity through wiring of latch actuator switches and interlock valve switch.	**Repair or replace wiring or connections as required.**
(2) Latch actuator switches out of adjustment at latch frames	Check switches for proper adjustment and **overtravel.**	Readjust latch switches.
(3) Latch unlock switch at interlock valve out of adjustment	Check switch for proper **adjustment and overtravel.**	Readjust switch.

D. "REVERSE THRUST" Light 'Flicks During Flight.

Possible Cause	Isolation Procedure	Correction
(1) Loose connection	Check for continuity through wiring of re**verse thrust switches** at the latch frames and engine torque box.	Repair or replace **wiring or connections as required.**
(2) Reverse thrust light switch at the engine torque box out of adjustment in relation to the lockout arm	Check switch for proper adjustment and overtravel. Refer to Engine Controls, 76-1-0.	Readjust switch.

E. Doors Reversing Too Slow.

Possible Cause	Isolation Procedure	Correction
(1) Oil level in CSD/ **thrust reverser oil tank is too low**	Check oil level.	Replenish oil tank. **Determine cause of** low supply.
(2) External leakage	Check lines for leaks.	Repair/replace defective line.
(3) Blocker door actuator sliders sticking	Check sliders for proper positioning and functioning.	Lubricate sliders **on upper and lower** support assemblies.
(4) Faulty relief valve		Replace relief **valve.**

F. Thrust reverse power can be applied before thrust reverser doors are in reverse position.

Possible Cause	Isolation Procedure	Correction
(1) Lockout interconnect **broken or loose**	Check tightness of lockout at nut at interconnect; check cable through **inspection hole in telescopic slider to ensure** that the cable end extends beyond hole.	Adjust cable per **Engine Controls,** 76-1-0.
(2) Bent or broken lockout arm	Check lockout arm.	**Replace engine torque box per Engine Controls,** 76-1-0.
(3) Idler or link rod, forward of thrust **reverse actuating mechanism, bent or broken**	Check idler and rod for **condition.**	Replace defective idler or link rod.

11. Fuel Contamination

A. Fuel Contamination Is Suspected.

NOTE: If fuel contamination is suspected, obtain fuel samples from the aircraft fuel tanks, engine high pressure filter drain and fuel control downstream of filter. Check fuel samples for solid or liquid contamination. Source of contamination must be determined if contamination is found. Remove and inspect main fuel filter and, based on findings, the following actions are to be taken:

Possible Cause	Isolation Procedure	Correction
(1) Filter is completely clogged	Remove all fuel nozzle **screens and inspect for contamination.**	
	(a) No contamination is found.	Replace fuel filter element. Inspect filter again after the next flight.
	(b) Screens are partially **clogged - no screen** is collapsed.	Replace fuel filter element. Replace all fuel **nozzles.** Inspect fuel filter and fuel nozzle **screens after the** next flight.
	(c) Screens are partially or totally clogged-- **one screen is col-** lapsed.	Replace engine with suspected fuel unbalance for hot **section inspection** and stage 3 blade replacement.
(2) Filter is partially clogged	**Remove two fuel nozzle screens and inspect for contamination.**	
	(a) No contamination is found.	Replace fuel filter. Inspect filter again after the next flight.

Possible Cause	Isolation Procedure	Correction
	(b) Screens are partially (30% of the total area) or totally clogged.	**Remove and inspect remaining screens.** Refer to Item (1).
(3) Filter shows light **or no sign of contamination**	**Remove one fuel nozzle screen and inspect for contamination.**	
	(a) No contamination is found.	**No action required.**
	(b) Screen is partially (30% of the total area) or totally clogged.	**Remove and inspect two other screens.** Refer to Item (2).

12. Reverse Hangups

NOTE: **Reverse hang-up is defined as failure to accelerate to maximum power in reverse thrust. Possible causes or contributing factors are** organized by the type of checks required to isolate them.

A. On the Wing Check - Engine Not Running.

NOTE: The following possible causes should be checked out first. These **checks are quick and simple and will save time and expense if the** problem can be isolated at this point.

Possible Cause	Isolation Procedure	Correction
(1) Compressor FOD	Check for any obvious damage in the early stages.	**Replace engine.**
(2) Damaged variable **vane linkage**	Check for missing pins and nuts. Check for any **obvious damage such as disengaged vane tangs, bent vane levers, bell-cranks, half rings, etc.**	**Replace engine.**

Possible Cause	Isolation Procedure	Correction
(3) Feedback cable sticking or binding, or VSRM defective	Disconnect feedback cable at the bellcrank and pull cable back and forth approximately one inch. Cable should move freely. Inspect VSRM.	Relieve cable bind and lubricate, or replace cable/conduit per 73-1-9. Replace VSRM per 73-1-10.

CAUTION: CABLE IS SPRING LOADED. DO NOT ALLOW CABLE TO SNAP BACK.

(4) Severely corroded or dirty compressor	Check rotor and stator for accumulation of dirt and carbon per (a). Check compressor again.. If severe pitting and rust discoloration are present take step (b).	(a) Water wash per ASIL No. 21B. (b) Pull engine and send to overhaul shop for walnut shell cleaning. With engine pulled also check stage-to-stage rigging per C.(1).

NOTE: To prevent accumulation of dirt and carbon, check operations for min. speed in reverse thrust. Min. limit is 80 knots. Reingestion below 80 knots will contaminate compressor. To prevent corrosion, use corrosion preventive measures specified in ASIL No. 21B.

(5) Leaking or damaged CDP line or power reduction system	Check lines for loose fittings or cracks.	Repair leakage. If leakage occurs in the circumferential or radial limiter tUbes in fan frame, remove engine for repair or replacement of tubes.
(6) Specific gravity setting too high (low fuel flow), setting too low (high fuel flow)	Check specific gravity setting on the fuel control. Nominal setting is 0.77.	Adjust specific gravity setting between 0.72-0.85 to obtain optimum operation.

NOTE: The specific gravity setting affects starting characteristics and acceleration characteristics in both forward and reverse thrust. All three modes of engine operation should be considered when changing this setting.

Possible Cause	Isolation Procedure	Correction
(7) P&D valve	**Disconnect drain line and measure fuel leakage. Excessive leakage** indicates. faulty valve.	Replace P&D valve per 73-1-6.
(S) Variable vane closed stops	Check closed stops per 72-0. Limit is ISo± 45'.	**Some operators** find better operation with stops set at 16°00' although this is not **true for every case. In no case** should the closed stops be set outside of 16° _ISO.

B. On the Wing Checks - Engine Running.

NOTE: The following possible causes are also checked on the wing but **require operational data in order to be checked out.**

Possible Cause	Isolation Procedure	Correction
(1) Running rig out of limits	Check running rig.	Adjust per Adjustment/Test, 72-0.
(2) Aircraft bleed **air system**	Check the bleed air system for leakage by making **accelerations with bleed** air on and off. Check **for large increases in acceleration with bleed air** off.	Refer to Air System, 75-0.
(3) Low idle speed	Check idle RPM.	Set idle to 62% **max. for best acceleration from** idle.
(4) Faulty CIT sensor	Make tracking check.	Replace CIT sensor per 73-1-5.
	(a) If parallel to schedule, **but above or** below by more than **tolerance, sensor is** faulty.	

Possible Cause	Isolation Procedure	Correction
	(b) If curves tend to intersect so that the schedule exceeds tracking check tolerance and cannot be corrected by a rigging change, the fuel control is faulty. **-or-** Check CIT sensor per 73-1-5.	
(5) Faulty fuel control	Make tracking check. If **curves tend to intersect** so that the schedule exceeds tracking check tolerance **and cannot be corrected** by a rigging change the fuel control is faulty.	Replace fuel control per 73-1-4.

C. Off the Wing Check.

NOTE: The following possible cause is the first that should be checked on any engine that has been pulled for reverse hang-ups.

Possible Cause	Isolation Procedure	Correction
(1) Stage-to-stage rigging	Check rigging.	Adjust to limits **specified in** 72-1-2.

ENGINE MAINTENANCE PRACTICES

1. **General.** **The maintenance of the engine must, of necessity, include all sys-**tems that are used on the engine during operation. When a system of the engine is covered in another chapter, references will be made to that chapter for details. Maintenance will be performed with the engine installed in the aircraft, thereby limiting the amount of work than can be done. For maintenance that requires major disassembly of the engine it will be necessary to remove the engine from the aircraft.

ENGINE MAINTENANCE PRACTICES - SERVICING

1. **General.** **The items that require serv1clng are listed in this section along** with the service to be performed.

WARNING: SYNTHETIC TURBINE LUBRICANTS WHICH ARE EXTENSIVELY USED IN AIRCRAFT TURBINE ENGINES, CONTAIN ADDITIVES WHICH ARE READILY ABSORBED THROUGH THE SKIN AND ARE CONSIDERED HIGHLY TOXIC. EXCESSIVE AND/OR PROLONGED EXPOSURE TO THESE LUBRICANTS TO THE SKIN SHOULD BE AVOIDED.

2. Lubrication and Scavenge System.

A. Check lube level in lube tank. (Refer to 72-5-0.)

B. Clean and check lube filter. (Refer to 72-5-3.)

C. Clean and check scavenge oil filter. (Refer to 72-5-7.)

3. Fuel System.

A. Clean and check fuel filter. (Refer to 73-1-3.)

4. Thrust Reverser System.

A. Clean and check thrust reverser oil filter. (Refer to 78-3-2.)

B. Lubricate the blocker hinge, upper beam track and the actuator guide tracks. (Refer to 78-1.)

MAINTENANCE PRACTICES - ADJUSTMENT/TEST

1. General. To have an engine that operates properly it is necessary to have it correctly adjusted. The checks for proper adjustment, and the adjustments themselves, can best be made during operation of the engine; therefore a functional run-up procedure is outlined in this section. This is followed by adjustment procedures and operating limits. Actually there are 2 procedures for engine operation - a prestart run and a functional run. The prestart run is a method of motoring the engine with the starter without firing the engine. This procedure should be followed when checking the engine for leaks, and when checking out the engine after installation, replacement of fuel system components or when the engine has not been operated for 72 hours. The functional run takes the engine through a full running cycle. This procedure should be followed for a newly installed engine, and for trouble-shooting an engine with a known malfunction. The functional test run is divided into a number of different categories, called checks. Each check has been selected to evaluate one particular phase of engine operations. Generally, only one or two of these checks need to be made on an engine, depending on the extent of the maintenance the engine has undergone.

2. Pre-Start Run Procedure (Pre-Test Motoring Checkout or Priming Run). This procedure is required after any maintenance which involves a fuel system component or an engine rotating part, or after installation of a new engine. The purpose of the pre-start run is to check the engine for free rotation and a leak-free fuel system before subjecting the engine to the speeds and temperatures involved in an actual engine start. The pre-start run also primes the fuel system on a newly installed engine or an engine which has lost its prime due to a fuel system component change. Proceed with the pre-start run only after inspecting the engine for loose hose connections and clearing the area of all loose debris, equipment and tools.

NOTE: Refer to Chapter 71 of Aircraft Maintenance Manual for this procedure.

3. Functional Test Run. The functional test run is intended to give an engine a thorough test for mechanical soundness and for correct indications of engine operating parameters. The functional test has been divided into categories, called "checkslt, which are defined in Table I.

TABLE I.

A. Engine Start Check

B. Idle Speed Check

C. Variable Stator Check

(1) Running rig check

(2) Tracking check

TABLE I (Cont.)

D. Take-Off Check

E. Deleted

F. Thrust Reverser Check

G. Engine Shutdown

After some types of maintenance, it will not be necessary to perform all of the above steps. Table 2 can be used as a guide to decide what checks are necessary after certain types of maintenance.

NOTE: These checks are used to ascertain proper overall operation of the engine and should be performed in addition to maintenance called for on the individual components.

TABLE II

Maintenance Work Done on Engine	Functional Checks Necessary
1. New engine installed	1. A - B - D - F - G
2. Fuel control or vsrrn change	2. A - B - C - D - F - G
3. CIT sensor changed	3. A - D - G
NOTE: It is permissible to use 96.5 percent RPM as an alternate for Take-Off Speed Check.	
4. Variable Vane Rigging Change	4. A - C(1) - G
5. Any other fuel system component changed	5. A - B - D - G
6. Lube systems component changed (except tank)	6. A - G
7. Lube oil tank	7. A - F - G
8. Transfer gearbox changed	8. A - D - G
NOTE: It is permissible to use 85 percent RPM as an alternate for Take-Off Speed Check.	
9. Rear gearbox changed	9. A - B - C(1) - D - F - G
NOTE: It is permissible to use 85 percent RPM as an alternate for Take-Off Speed Check.	

A. Engine Start Check.

B. Idle Check.

NOTE: For engine start check and the idle check, refer to Chapter 71, Power Plant - General of the Aircraft Maintenance Manual.

C. Variable Stator Check.

This check consists of 2 parts: a running rig check and a tracking check. The running rig is the vane angle when the engine speed is at 7200 rpm **corrected; the tracking check covers all angle-speed relationships.**

NOTE: A master tachometer indicator accurate to ± 0.25 percent engine speed should be used when checking the variable stator schedule. The BH 112J-28T2 Jetcal Analyzer, when periodically calibrated, **contains a tachometer of sufficient accuracy. Ambient temperature** (from a thermometer located near the aircraft and sheltered from effects of unnatural heat and wind) may be used for compressor inlet temperature (CIT).

(1) Install the variable stator angle monitor (2C4019) transmitter on the third vane below the left horizontal flange of the second stage **of vanes, looking forward from the rear of the engine.**

NOTE: Periodic calibration of the monitor is required. To do this place the transmitter on the dummy stator studs in the indicator box and lock in position then zero the indicator with the knurled knob on the upper right hand corner of the indicator **face.**

(a) Align the slot of the transmitter's spring loaded locating shaft with the tang on the third variable stator vane.

(b) Screw the transmitter holding shaft onto the stud of the third vane and tighten.

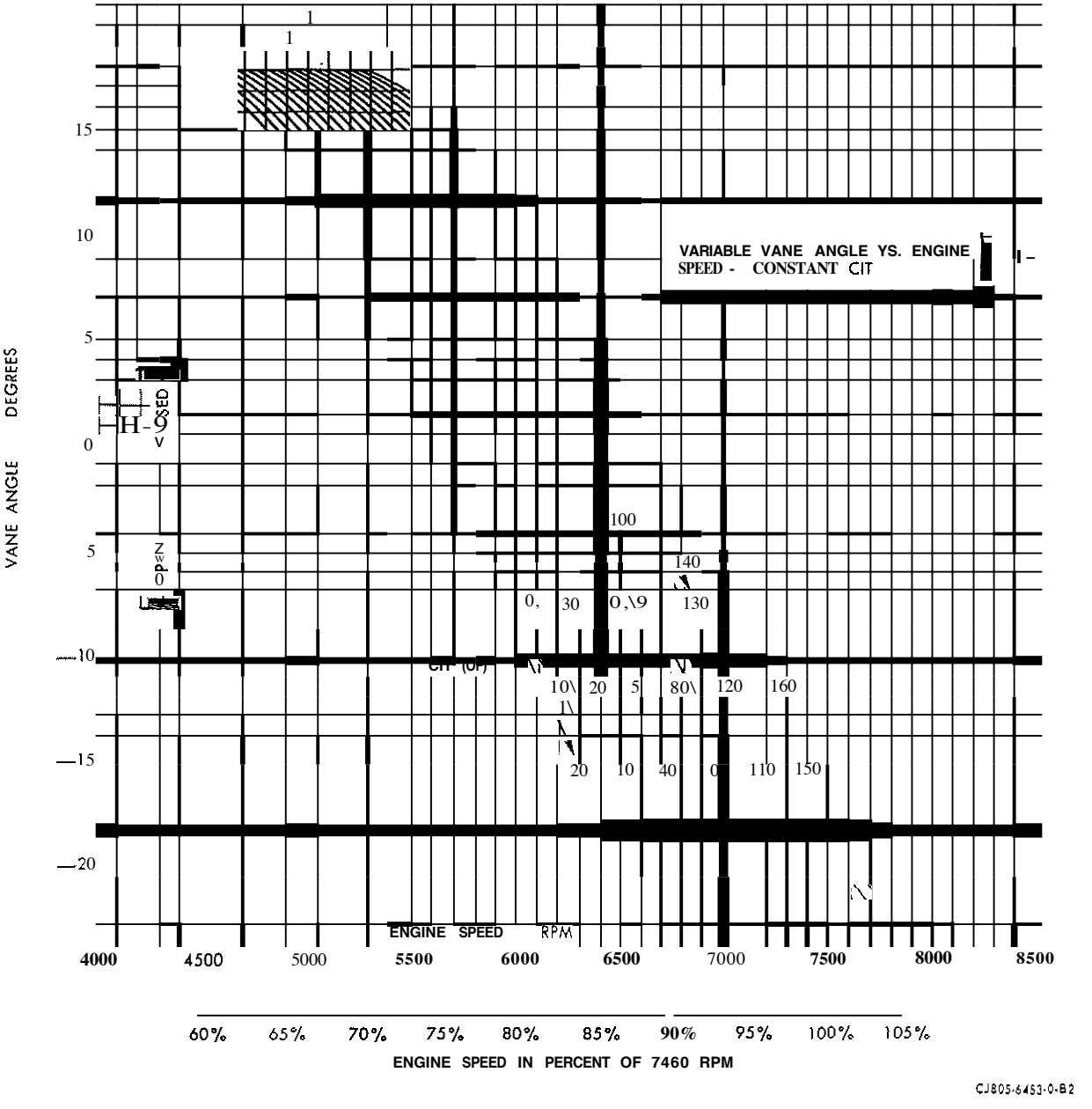
(c) Screw the two position locking screws on the transmitter out riggers to the 2nd and 4th stator vanes respectively and tighten.

(d) Connect the electric extension cable between the transmitter and **indicator box and the power cable between the indicator box and** the 400 cycle 115 volt power source.

(2) Check the running rig as follows:

CAUTION: DO NOT BUMP AGAINST THE VARIABLE STATOR FEEDBACK CABLE OR USE IT AS A HAND GRIP WHEN PASSING UNDERNEATH THE ENGINE. A DEFLECTION OF THIS CABLE CAUSES A SHIFT IN VARIABLE STATOR SCHEDULE.

(a) Start the engine and make a slow acceleration to a speed corres-ponding to approximately 1-1/2 percent higher than figure 502, then decelerate to a corrected speed of 7200 rpm ± 20 rpm.



Variable Stator Schedule
Figure 501

CIT of	N %	NRPM
-20	88.9	6629
-18	89,1	6644
-16	89.3	6659
-14	89,5	6674
-12	89,7	6689
-10	89,9	6704
-8	90,1	6719
-6	90.3	6733
-4	90.5	6749
-2	90.7	6763
0	90,9	6778
2	91.1	6792
4	91.3	6808
6	91.4	6822
8	91.6	6837
10	91.8	6851
12	92,0	6866
14	92.2	6878
16	92,4	6895
18	92,6	6910
20	92,8	6924
22	93,0	6938
24	93,2	6952
26	93.4	6967
28	93.6	6981
30	93.8	6996
32	94.0	7010
34	94,2	7024
36	94,4	7039
38	94.5	7053
40	94.7	7067
42	94.9	7081
44	95.1	7095

CIT OF	N %	N RPM
46	95.3	7109
48	95.5	7123
50	95,7	7137
52	95.9	7151
54	96,1	7166
56	96,2	7179
58	96,4	7193
60	96.6	7207
62	96.8	7221
64	97,0	7235
66	97.2	7249
68	97.3	7262
70	97.5	7276
72	97,7	7290
74	97.9	7303
76	98.1	7317
78	98,3	7330
80	98,4	7344
82	98.6	7358
84	98,8	7372
86	99,0	7385
88	99.2	7398
90	99,4	7412
92	99,5	7426
94	99,7	7439
96	99.9	7453
98	100,1	7466
100	100.3	7479
102	100.4	7493
104	100,6	7505
106	100.8	7519
108	101,0	7532
110	101.2	7546

Indicated Engine Speed vs. CIT for $N/\sqrt{\theta_2}$ 7200 RPM
Figure 502

NOTE: The proper physical speed that corresponds to a corrected speed of 7200 rpm is given in the following table (figure 502). Enter the table with the compressor inlet temperature and read off the physical speed corresponding to 7200 rpm corrected.

(b) Check the variable vane angle. It should be 21 degrees, 0 minutes ± 30 minutes. If the angle is within ± 1 degree, 30 minutes adjust the feedback cable to within the ± 30 minutes tolerance. If vane angle is not within ± 1 degree, 30 minutes of 21 degrees, check the static rig point per 73-1-4.

NOTE: On rack and pinion feedback systems the adjustment is made by backing off the jam nut and turning the feedback cable. Use the wrench flat on the cable to make the adjustment.

CAUTION: ONLY RACK AND PINION SYSTEMS CAN BE ADJUSTED BY TURNING THE CABLE. DO NOT ATTEMPT TO TURN CABLE ON SHEAVE WHEEL TYPE FEEDBACK SYSTEMS.

(3) Make a tracking check as follows:

(a) Start the engine and make a slow acceleration to a speed corresponding to approximately 1-1/2 percent higher than figure 502, then decelerate to a corrected speed of 7200 rpm ± 20 rpm.

NOTE: The proper physical speed that corresponds to a corrected speed of 7200 rpm is given in figure 502. Enter the table with CIT and read-off the physical speed corresponding to 7200 rpm corrected.

(b) Check the stator vane angle. It should be 21 degrees, 0 minutes ± 30 minutes. If not adjust.

NOTE: If the angle is not off more than ± 1 degree, 30 minutes the feedback should be adjusted. If the angle is off more than ± 1 degree, 30 minutes, check the static rig point per 73-1-4.

(c) Decelerate the engine to 20 percent less than physical speed for 7200 rpm corrected and check the vane angle. The angle must be within ± 1-1/2 degrees of figure 501.

(d) Accelerate to the 7200 ± 20 rpm corrected speed point. Check the vane angle at this speed, it must be within ± 1 degree, of the **reading taken at deceleration check.**

(c) Decelerate the engine to 20 percent less than physical speed for 7200 rpm corrected and check the vane angle. The angle must be within ± 1-1/2 degrees of figure 501.

(d) Accelerate to the 7200 ± 20 rpm corrected speed point. Check the vane angle at this speed, it must be within ± 1 degree, of the reading taken at deceleration check.

D. Take-off Check. Functional check of engine parameters at take-off power.

E. Deleted.

F. Thrust Reverser Check. Functional check of thrust reverser operation (open to close to open).

G. Engine shutdown. Functional check to ensure engine shutdown with throttle in cut-off position.

NOTE: For engine take-off check, thrust reverser check and engine shutdown, refer to Chapter 71, Power Plant - General of the Aircraft **Maintenance Manual.**

H. Variable Stator Check. (Alternate Procedure) This procedure applies only when running rig cannot be obtained before EGT limits are reached.

(1) Check the running rig as follows:

(a) Accelerate engine slowly to an rpm approximately 1 to 1-1/2 percent above the rpm for the appropriate CIT as specified in Table III. Then decelerate slowly to a corrected speed of 7125.

NOTE: The proper physical speed that corresponds to a corrected speed of 7125 rpm is given in TABLE III. Enter the table with the compressor inlet temperature and read off the physical speed corresponding to 7125 rpm corrected.

(b) Read the vane angle. It must be 20°0' ± 30' open. If vane angle is incorrect, adjust per paragraph C.(2)(b) or (c).

(2) Make a tracking check as follows:

(a) Start the engine and make a slow acceleration to a speed corresponding to approximately 1-1/2 percent higher than TABLE III, then decelerate to a corrected speed of 7125 rpm ± 20 rpm.

NOTE: The proper physical speed that corresponds to a corrected speed of 7125 rpm is given in TABLE III. Enter the table with CIT and read-off the physical speed corresponding to 7125 rpm corrected.

(b) CheCk the stator vane angle. It should be 20 degrees, 0 minutes ± 30 minutes. If not, adjust.

NOTE: If the angle is not off more than ± 1 degree, 30 minutes the feedback should be adjusted. If the angle is off **more than ± 1 degree, 30 minutes,** check the static rig point per 73-1-4.

(c) Decelerate the engine to 20 percent less than physical speed for 7125 rpm corrected and check the vane angle. The angle must be within ± 1-1/2 degrees of Figure 501.

(d) Accelerate to the 7125 ± 20 rpm corrected speed point. Check the vane angle at this speed, it must be within ± 1 degree, of the reading taken at deceleration check.

TABLE III

INDICATED ENGINE SPEED VS. CIT FOR $N/\sqrt{\theta 2}$ = 7125 RPM

CIT °F	NRPM		CIT °F	NRPM	N%
-20	6560	87.9	36	6966	93.4
-18	6574	88.1	38	6980	93.6
-16	6589	88.3	40	6993	93.7
-14	6604	88.5	42	7007	93.9
-12	6619	88.7	44	7021	94.1
-10	6633	88.9	46	7035	94.3
- 8	6648	89.1	48	7049	94.5
- 6	6663	89.3	50	7063	94.7
- 4	6678	89.5	52	7076	94.9
- 2	6693	89.7	54	7091	95.1
0	6708	89.9	56	7104	95.2
2	6722	90.1	58	7118	95.4
4	6737	90.3	60	7132	95.6
6	6751	90.5	62	7146	95.8
8	6766	90.7	64	7160	96.0
10	6780	90.9	66	7173	96.2
12	6795	91.1	68	7186	96.3
14	6810	91.3	70	7200	96.5
16	6823	91.5	72	7214	96.7
18	6838	91.7	74	7227	96.9
20	6852	91.9	76	7241	97.1
22	6866	92.0	78	7254	97.2
24	6880	92.2	80	7267	97.4
26	6894	92.4	82	7281	97.6
28	6908	92.6	84	7295	97.8
30	6923	92.8	86	7308	98.0
32	6937	93.0	88	7321	98.1
34	6951	93.2	90	7335	98.3

D. Take-Off Check

E. Deleted.

F. Thrust Reverser Check

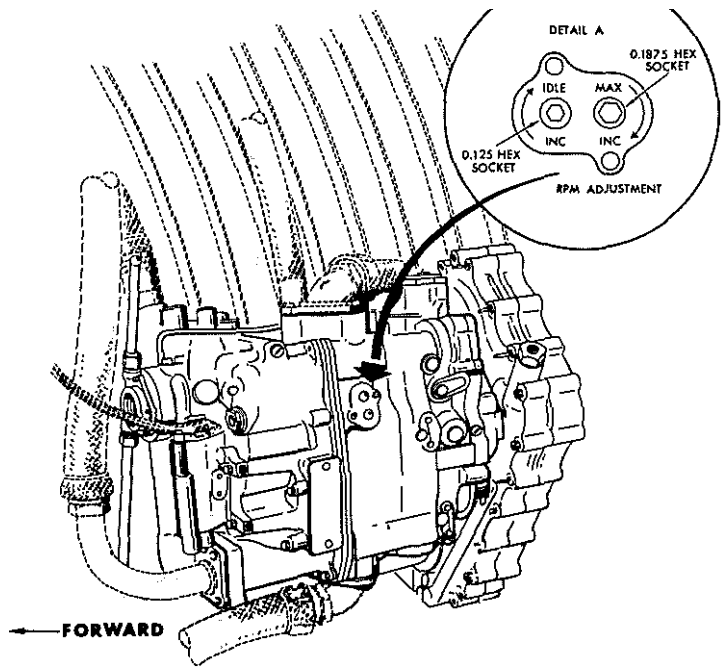
G. Engine Shutdown

NOTE: For engine take-off check, thrust reverser check and engine shutdown, refer to Chapter 71, Power Plant - General of the Aircraft **Maintenance Manual.**

4. Deleted.

5. Adjustments. Field adjustments other than the running rig adjustment, are maximum speed and idle speed. They should be checked in the order listed below. No other adjustments may be made without proper facilities and the **manufacturer's approval.**

A. Maximum Speed. This adjustment is located on the fuel control (figure 503). To increase speed, turn adjustment clockwise. Speed changes



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Fuel Control Adjustments
Figure 503

approximately 1/8 percent per click. When ambient air temperature is below 15°C, consult chart in figure 508 to determine if an adjustment is necessary. This adjustment should only be set when using a master instrument calibrated tachometer or its equivalent, with an accuracy of at least ± 0.25 percent. Recheck idle speed after every maximum speed adjustment.

B. Idle Speed. This adjustment is located on the fuel control (figure 503). **To increase idle speed, turn the adjustment clockwise. Speed changes** approximately 1/3 percent per click. Idle speed is affected by the top speed adjustment. Recheck whenever maximum speed is adjusted.

6. Engine Operation Limits.

A. Starting Time. Starting time is defined as the time from movement of the fuel shut-off lever to the RUN position until 60 percent (4475 rpm) engine speed is attained. Normally this time should not exceed 60 seconds. **A minimum of 3 minutes must be allowed between successive engine ground** starting attempts to permit proper fuel drainage.

NOTE: Under low ambient temperature (or cold soak condition) accompanied **by low starter air pressure, the time to idle will exceed 60 seconds. The start may be continued providing engine condition is** normal (free of damage) and engine continues to accelerate to idle without exceeding EGT limits. If engine does not accelerate to idle or exceeds EGT limit, abort the start and take corrective **action to increase starter air pressure.**

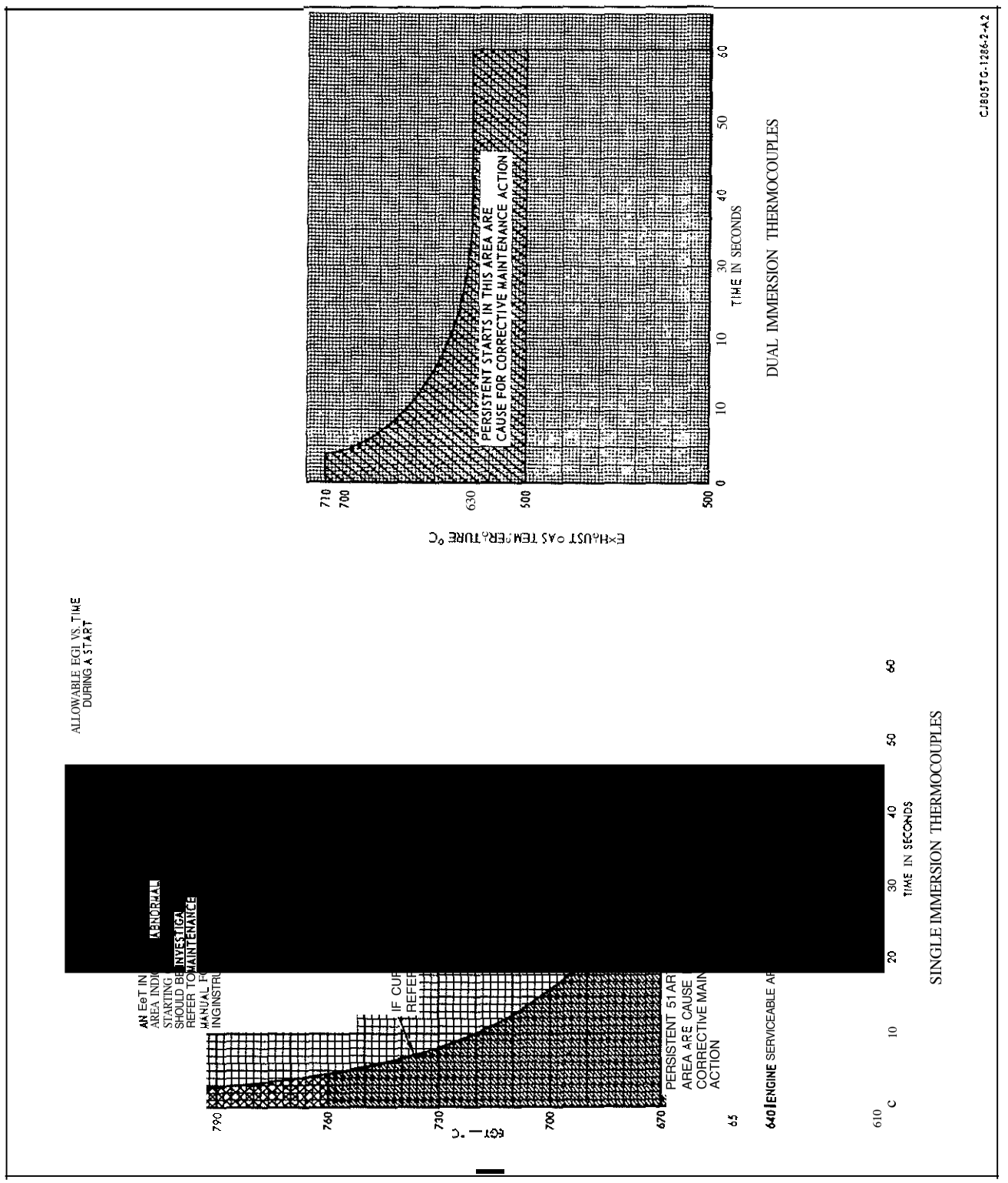
B. Engine Speed. One hundred percent engine speed is equivalent to 7460 rpm.

(1) The following lists the engine speed operating limits for normal conditions. Refer to Inspection/Checks for over limit operation.

Power Setting	Engine Speed
TAKE-OFF	Not to exceed 103 percent
IDLE	**60 percent ± one percent** 4475 rpm ± 75 rpm

(2) Fan Speed. One hundred percent fan speed is equivalent to 6000 fan rpm. The maximum operating limit for normal conditions is 99.4 percent (5965 fan rpm) .

NOTE: The engine speed is limited to 85 percent at any time bypass **air ducts of the engine pod are open, as in engine run-up during maintenance operation.**



Exhaust Gas Temperature Limits - Starting
Figure 504

C. Exhaust Gas Temperature (EGT).

(1) EGT During Start. The EGT limits for the engine during start are given in figure 504. The area under the curve describes the allowable combination of times and temperature, while the area above the curve describes an overtemperature condition that requires replacement of the engine.

NOTE: An EGT which falls in the cross-hatched area under the curve indicates an abnormal, but serviceable, starting condition that should be investigated. (Refer to trouble-shooting section.)

(2) Power Setting Time Limits. The following table lists allowable time at different power settings for both the -23 and -23B engines.

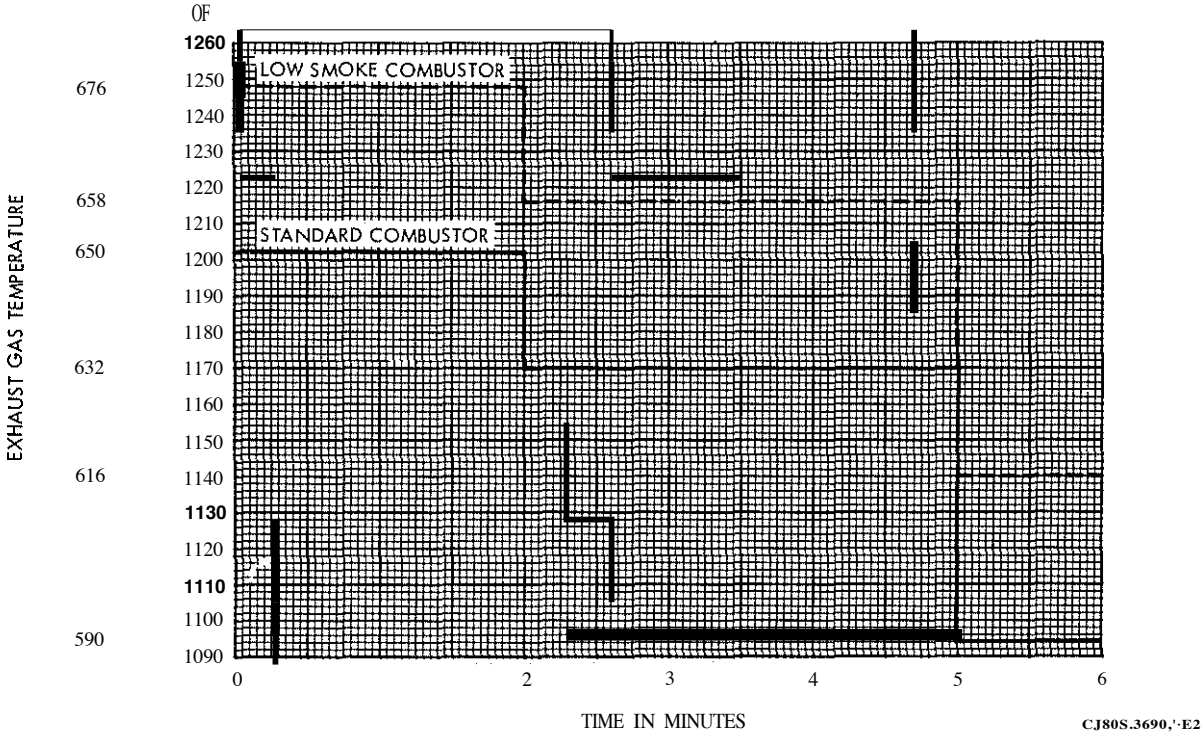
Temperature

Power Setting	Time Duration Standard Combustor	Low Smoke Combustor
TAKE-OFF (Transient limit)	650°C 2 minutes Max	676°C 2 minutes Max
TAKE-OFF (Normal limit)	632°C 5 minutes	65SoC 5 minutes
MAX CONTINUOUS	590°C Continuous	616°C Continuous

(3) Transient EGT Limits. During take-off and all other modes of operation, exhaust gas temperature should not extend above the normal limits of sub-paragraph "(2)" or figure 505. If the time - temperature intersection falls on a point on or below the curve, the engine is serviceable and no check or parts replacement is necessary. If the over-temperature falls on a point above the curve the engine must be given an over-temperature inspection, except for a transient condition. Refer to 72-0, Inspection/Check for over-temperature inspection/check. Transient conditions, with a temperature up to 700°C and time not to exceed 5 seconds, are permitted Without an over-temperature inspection. However, the transient condition does indicate an abnormal but serviceable condition which should be investigated (Refer to Troubleshooting Section).

D. Lube Oil Pressure and Temperature. Each engine has a characteristic oil pressure at every speed setting. Check engine records and investigate any deviation of more than ± 10 psi from normal for a particular engine.

FIGURE 504A. DELETED

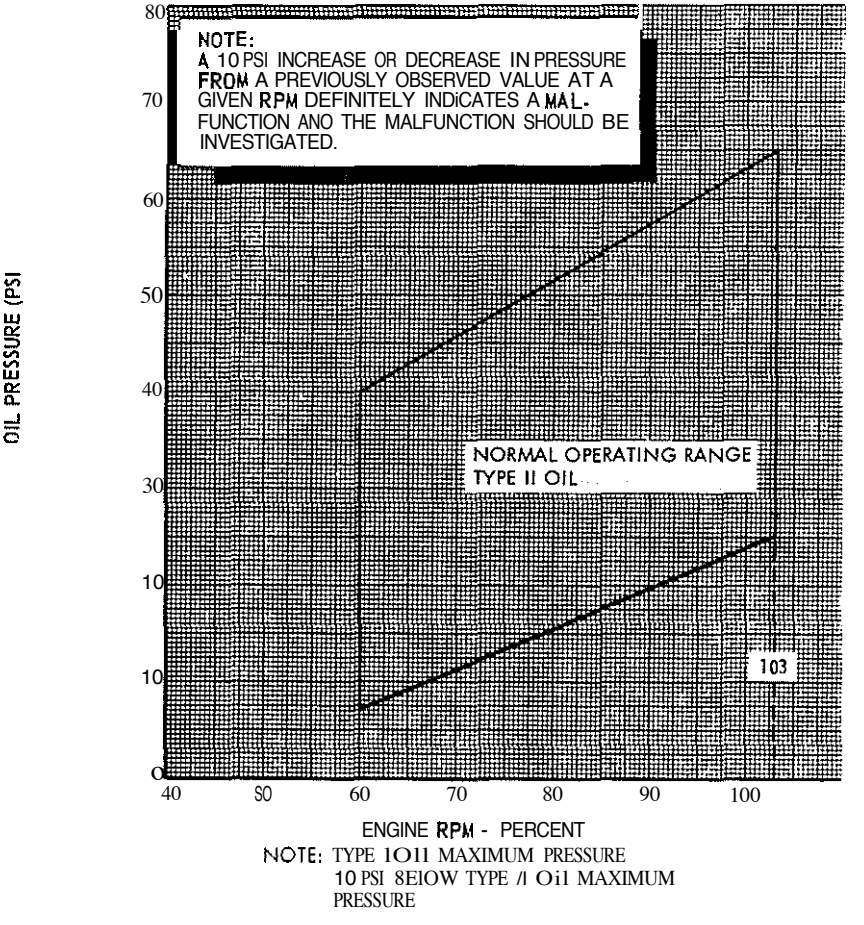


Allowable Transient EGT at all Times Except Starting
Figure 505

See figure 506 for operating limits. The limits of figure 506 apply **when the temperature of the scavenge oil is within the normal range of** 3SoC to 149°C. Scavenge oil temperature must not exceed 149°C. Oil **pressure increases as temperature decreases.**

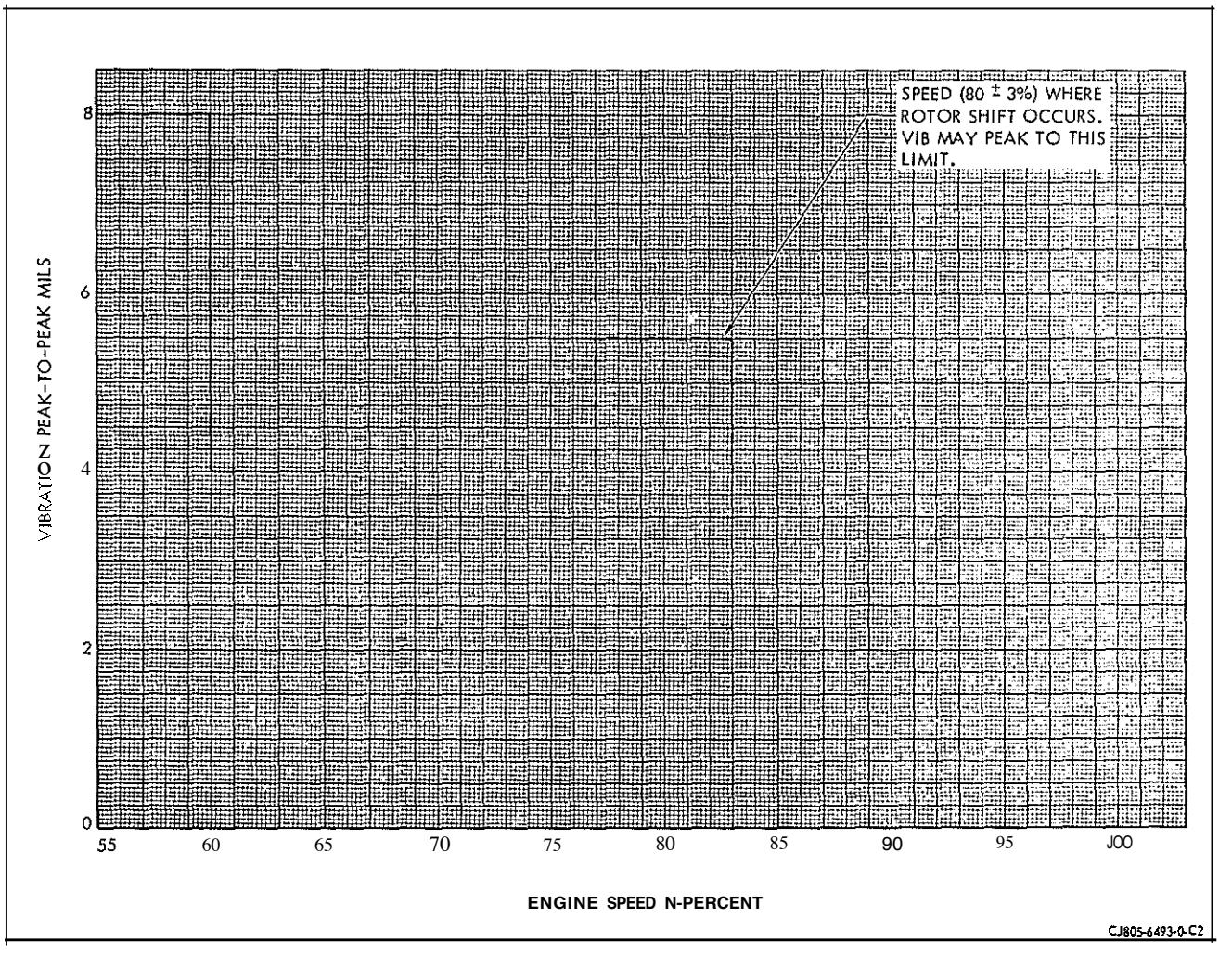
NOTE: Once the normal engine oil pressure level is constant, it then is **important to monitor oil pressure trends and rapid pressure** changes for troubleshooting the engine.

E. Maximum Allowable Lube Oil Consumption. Three pints per hour (3 pounds per hour).



Oil Pressure Limits
Figure 506

F. Anti-Icing Limits. Do not operate the anti-icing system longer than 20 minutes at IDLE or 30 seconds at any higher power setting when the compressor inlet temperatures are 15°C (59°F) or above. Engine anti-icing may be operated continuously at any power setting when the compressor **inlet temperature is below 15°C. For checking, or where there is a suspected** failure which would allow unregulated heat to the front frame, the engine may be operated with the anti-ice system on or suspected to be on with a compressor inlet temperature with 15°C for a period not to exceed five minutes at idle power (60% RPM). Use of anti-icing air when compressor inlet temperatures are above 15°C (59°F) should be kept to the absolute minimum necessary for adequate ground checking or trouble-shooting, and in no case exceed the limits described above.

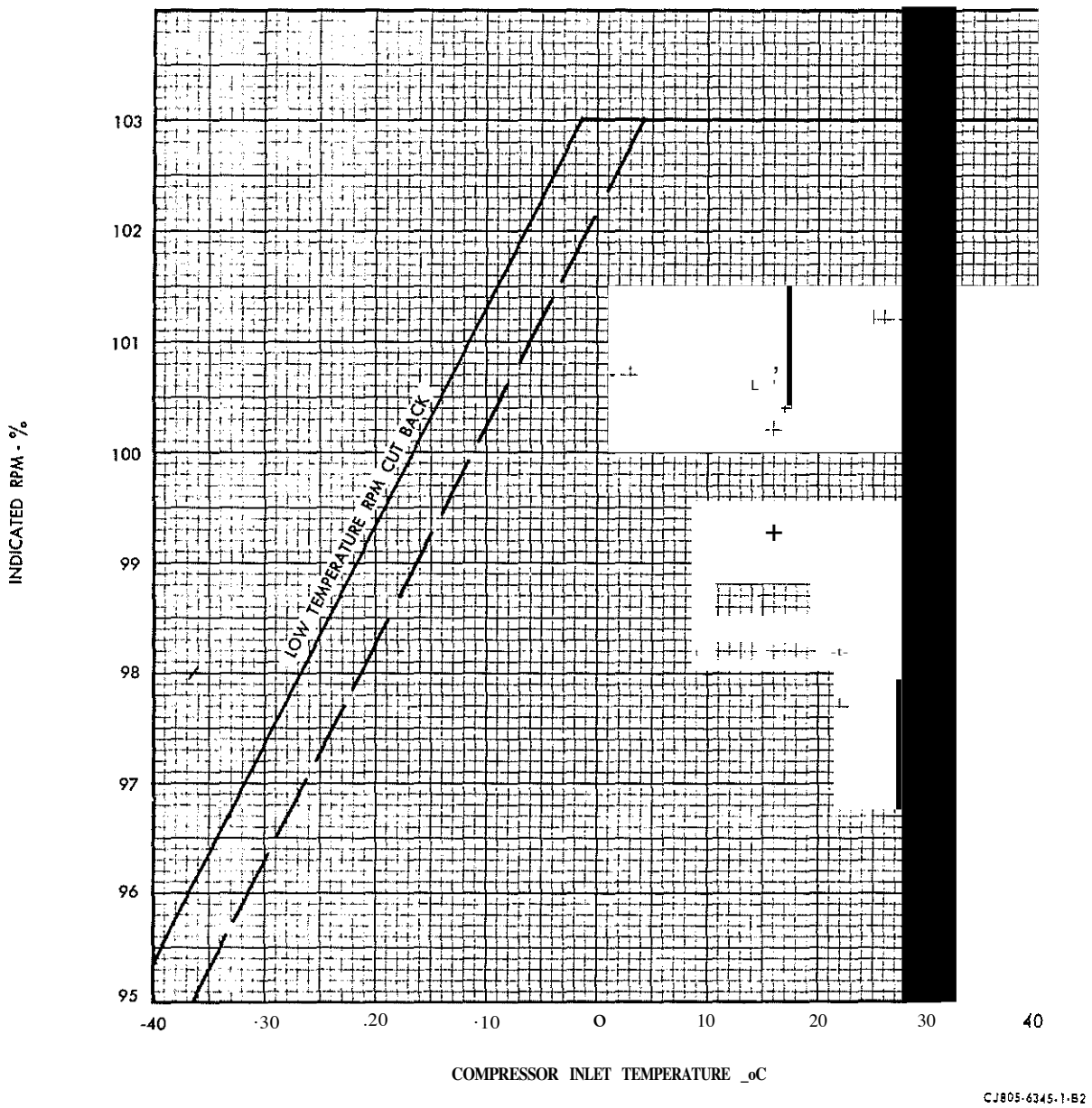


Vibration Limits
Figure 507

G. Variable Stator Schedule: Refer to the curve in figure 501 to find correct variable stator position. The limits are ± 1-1/2 degrees at any point except 7200 rpm corrected speed. The angle at 7200 rpm corrected **speed is 21 degrees, 0 minutes ± 30 minutes.**

H. Fuel Contamination Limit. All fuel used by the engine must be passed **through a IO-micron screen.**

I. Vibration Limits. Must be within limits of figure 507.



Top Speed Setting Curve
Figure 508

ENGINE MAINTENANCE - INSPECTION/CHECKS

1. General. **In order to maintain the engine it is necessary to make inspection/checks of certain areas periodically. These areas are designated here. There are also inspections/checks that are necessary when the engine has been operated outside of specified limits, e.g., over-speed or over-temperature. These will be called out here in order to provide disposition of such engines.**

2. Over-Limit Inspection/Checks.

A. Over-temperature inspection.

NOTE: Any over-temperature condition will require removal of the engine in order to perform the required inspection. For an evaluation of allowable time at any temperature, refer to 72-0 Adjustment and Test, paragraph 6.

(1) The turbine rotor and fan rotor must be given a detailed inspection **per the overhaul manual.**

(2) The remaining turbine section parts, fan section parts and all of the combustion section must be inspected for damage per the overhaul manual.

B. Basic engine over-speed inspection. The maximum allowable engine over-speed is 105 percent (7833 rpm). **If this limit is exceeded, record maximum speed and duration of overspeed and return the engine to overhaul.**

NOTE: If engine is subjected to an over-speed condition, the engine must be removed from the aircraft for inspection.

C. Fan over-speed inspection/checks.

(1) **If the fan is operated at speeds from 99.4 percent rpm to 102.5 per-cent rpm, the rotor must be visually inspected. This can be done** with fan rotor still in the fan package.

(2) **If the fan is operated above 102.5 percent (6150 rpm) the engine must be returned to overhaul.**

D. **Over-limit anti-icing inspection/check. Whenever the anti-icing system** is operated outside the limits given in the engine adjustment and test **section the following inspection must be made.**

(1) Visually inspect/check the engine inlet as follows:

(a) Check for oil leaks that are evidenced by oil wetting of the **trailing edge of the inlet guide vanes, the inlet guide vane support and the front frame at 6:00 o'clock location strut.**

(b) Check for inlet gUide vane rub on the front frame lGV support. Check particularly in the 2:30 and 9:30 o'clock location strut.

(c) Check for 1st stage compressor rotor blade rub against the compressor stator casing. Check particularly in the 2:30 and 9:30 **o'clock positions. If rubs are found, manually open the inlet guide vanes and check the clearance between the 1st stage compressor rotor blades and the compressor stator casing at the** 2:30 and 9:30 o'clock position. Minimum clearance is 0.030 inch.

NOTE: If the high blade marking is present (usually blue or yellow band) on the blade tip, only the high blade need be checked, otherwise all blades should be checked for **clearance.**

(d) Check oil filters for contamination. (Refer to 72-5-3.)

(2) If any of the above conditions exist the engine must be removed and **the front frame repaired or replaced.**

E. Over-limit inspection/check for "No Oil Pressure" engine operation or windmilling: If an engine has been operated or windmilled with "no oil pressure" the following inspection/checks must be made.

(1) Check the lubrication and scavenge oil filters for contamination. If **normal, continue inspection/check, if abnormal, reject engine and return to overhaul.**

(2) **Correct cause of "no oil pressure". Service oil tanks.**

(3) **Motor engine and check for abnormal noises. If none, continue inspection/check, if abnormal, reject engine and return to overhaul.**

(4) Start engine and operate at idle speed. If operation is normal, run the engine for 15 minutes; 1 minute at 2 to 3 percent below take-off power and remainder at idle speed.

(5) Check the lubrication and scavenge oil filters for contamination. If **normal, engine is serviceable, if abnormal, reject engine and return to overhaul.**

F. Inspection of Engine Involved in an Accident or Incident. Engines involved in an accident or incident require special inspections that exceed normal Inspection. For special instructions relative to engine parts contact the General Electric Company, Commercial Engine Division, Cincinnati, Ohio 45215, Attention: Manager, CJ805/CSD Programs.

G. Fire Extinguishing Agents Externally. If the engine has been exposed to **fire extinguishing agents on external surfaces, accomplish the following as appropriate.**

NOTE: Contact a GE Representative for additional work scope and/or disposition.

(1) C02' Engine parts which are at elevated temperature when exposed to **C02 must be removed for inspection per the Overhaul Manual. Parts which are unheated require no maintenance action.**

(2) Foam Agents.

(a) Wash with clean water and brush to remove all foam agent.

CAUTION: DO NOT ALLOW FOAM TO ENTER ANY ENGINE CAVITIES. FOAM RESIDUE MAY CAUSE CORROSION DAMAGE.

(3) Dry Chemical Powder Agents.

(a) Clean all loose powder from engine using vacuum tools and compressed air (30-40 psi) as required.

CAUTION: DO NOT USE WATER. DRY AGENT COMBINES WITH WATER TO FORM AN EVEN MORE CORROSIVE COMPOUND.

(b) If powder has turned to glaze due to elevated temperatures, scrub with a mixture of 60 percent isopropyl alcohol/40 percent isobutyl **alcohol until all glaze is removed and then steam clean.**

CAUTION: DO NOT ALLOW AGENT TO ENTER ANY ENGINE CAVITIES. RESIDUE WILL CAUSE CORROSION DAMAGE.

H. Fire Extinguishing Agents Internally. If the engine has been exposed to **fire extinguishing agents on internal surfaces, accomplish the following as appropriate.**

NOTE: Contact a GE Representative for additional work scope and/or **disposition.**

(1) CO_2. Remove parts exposed to C02 for inspection per the Overhaul Manual.

(2) Foam Agents. Flush with clean water and motor engine (if possible) **to remove foam residue. Remove engine for disassembly, inspection, and cleaning per the Overhaul Manual.**

(3) Dry Chemical Powder Agents. Remove all accessible loose powder by utilizing vacuum tools and compressed air (30-40 psi). Rinse with a mixture of 60 percent isoproply alcohol/40 percent isobutyl alcohol. **Dry motor to clear and dry engine. Remove engine for disassembly and cleaning per the Overhaul Manual.**

3. Daily Checks.

A. Check the engine inlet area. (Refer to Item 6A, Detail Area Inspect/Check.)

B. Check the engine exit area. (Refer to Item 6B, Detail Area Inspect/ Check.)

C. Check oil level in both compartments of the oil tank. (Refer to 72-5-0.)

4. Periodic.

A. Perform daily checks.

B. Check the engine externally. (Refer to Item 6C, Detail Area Inspect/ Check.)

C. Inspect/Check engine trunnion mounts. (Refer to Item 6D, Detail Area Inspect Check.)

D. Check hot section for defects. (Refer to Item 6E, Detail Area Inspect/ Check.)

E. Service lube oil filter. (Refer to 72-5-3.)

F. Service scavenge oil filter. (Refer to 72-5-7.)

G. Service fuel filter. (Refer to 73-1-3.)

H. Service thrust reverser oil filter. (Refer to 78-3-2.)

I. Service thrust reverser blocker bearings, actuator slider tracks and upper beam track. (Refer to 78-1.)

5. Functional List of Periodic Inspection/Checks.

	Inspect/Check At: Daily	Periodic
A. Compressor Section		
(1) Compressor inlet	x	x
(2) Variable vane linkage		x
(3) Front frame; externally for damage		x
(4) Compressor Stator Casings; externally for damage		x
(5) Compressor Rear Frame; externally for damage		x
B. Combustion Section		
(1) Outer Combustion Casing; externally for damage		x
C. Turbine Section		
(1) Turbine Stator Casing; externally for damage		x
D. Fan Section		
(1) Fan Front Frame		
(a) Externally for damage		x
(b) Fan inlet for cracks in liners		x
(c) Fan secondary flow path for FOD		x
(2) Fan Rear Frame, externally and internally for damage	x	x
E. Exhaust Section		
(1) Thrust Reverser; externally for damage	x	x
(2) Primary and Secondary Nozzles; externally for damage	x	x
(3) Inner exhaust cone for damage	x	x
(4) Service thrust reverser oil filter		x
(5) Service thrust reverser blocker bearings, actuator slider tracks and upper beam track		x

	Inspect/Check At: Daily	Periodic
F. Accessory Drive Section		
(1) Transfer Gearbox; externally for damage		x
(2) Horizontal Drive Shaft Housing; externally for damage.		x
(3) Damper Bearing; externally for damage.		x
(4) Rear Gearbox; externally for damage. .		x
G. Lubrication System		
(1) Check for leakage.		x
(2) Service lube oil filter.		x
(3) Service scavenge oil filter.		x
(4) Check for damaged lines.		x
H. Fuel and Control System		
(1) Check for leakage. .		x
(2) Service fuel filter.		x
(3) Check for damaged lines.		x
(4) Check for binding in throttle linkage.		x
I. Ignition System		
(1) Check for loose connections.		x
J. Indicating.Systems		
(1) Check for loose connection on thermocouples and tach. generator.		x
K. Air Systems		
(1) Check for loose connection of external lines - - - - -		x
(2) Check for blown gaskets at anti-icing, cabin bleed and leakage port connections .		x

6. Detail Area Inspection/Check.

A. Check the engine inlet for damage. Use a mirror and a flashlight to **visually check hard-to-see areas.** The following are specific items to be checked:

(1) Check front frame for damage. (Refer to paragraph 72-1-1 for limits.)

(a) struts for nicks and cracks.

(b) Inlet gUide vanes for nicks and cracks.

(c) Check for inlet guide vane rubbing on the IGV support or frame.

(d) Check for oil leakage as evidenced by oil wetting of the trailing edge of the inlet guide vanes, and the inlet guide vane support at the split line. Check particularly in the lower half of the frame.

(e) Unmachined areas of hub and outer casing for nicks and scratches.

(f) All surfaces for corrosion and loss of protective finish.

(g) Compressor inlet temperature sensing elements for leaks. (Refer to 73-1-5.)

(2) Check compressor rotor for damage. (Refer to paragraph 72-1-4 for limits.)

(a) Rotor blades for cracks, nicks, dents and scratches.

(b) Rotor blades for tip curl.

(3) Check compressor stator for damage. (Refer to paragraph 72-1-2 for limits.)

(a) Stator vanes for nicks and cracks.

(b) Stator casings for nicks, scratches and cracks.

(c) Check the stator for 1st-stage compressor rotor blade rub.

NOTE: If rub is found, check the clearance between the **first-stage compressor rotor blades and the compressor stator** casing at 2:30 and 9:30 o'clock position. Minimum clearance is 0.030 inch.

B. Check the engine exit area for damage.

(1) Check reverser blocker doors for cracks or distortion. (Refer to 78-1.)

(2) Check the primary and secondary nozzles for cracks and distortion. (Refer to 78-2.)

(3) Check the inner exhaust cone for cracks. (Refer to 78-2.)

(4) Check the thrust reverser linkage. (Refer to 78-1.)

(5) Check the fan rear frame for damage. (Refer to 72-6-4.)

(6) Check the fan rotor blades for damage. (Refer to 72-6-2.)

(7) Check the fan rotor shroud for damage. (Refer to 72-6-3.)

C. Check the engine externally for the following defects.

(1) Check visually for evidence of fuel and oil leakage.

(a) Check fuel leakage. (Refer to chapter 73 for corrective action.)

(b) Check oil leakage. (Refer to 72-5-0 for corrective action.)

(2) Check external hardware.

(a) Check for loose or missing clamps.

(b) Check variable stators for missing clips or pins.

(c) Check for loose or missing nuts and bolts.

(3) Check accessory mounts.

(a) Check for cracked mounts.

(b) Check for leakage.

(c) Check for loose bolts or nuts.

(4) Check gearboxes for damage.

(a) Check for gearbox cracks, particularly around accessory mounting pads.

(b) Check gearbox mounting bosses for cracks.

D. Inspect engine trunnion mounts for the following damage or defects.

(1) Check front trunnion mount. (Refer to 72-1-5.)

(a) Check bolts for security.

(b) Inspect/check for cracks.

(2) Inspect/check front fan frame trunnion mount.

(a) Check mounting pins for security.

(b) Inspect/check for cracks. (Refer to 72-6-1.)

E. Check external areas of hot section for the following defects.

(1) outer combustion casing (Refer to 72-2-1 for limits.)

(a) Distortion

(b) Cracks

(c) Hot spots

(2) Turbine stator casing, externally (Refer to 72-3-2 for limits.)

(a) Distortion

(b) Cracks

(c) Hot spots

(3) Fan Front Frame, externally (Refer to 72-6-1.)

(a) Cracks

(b) Distortion

(4) Fan Rear Frame, externally (Refer to 72-6-4.)

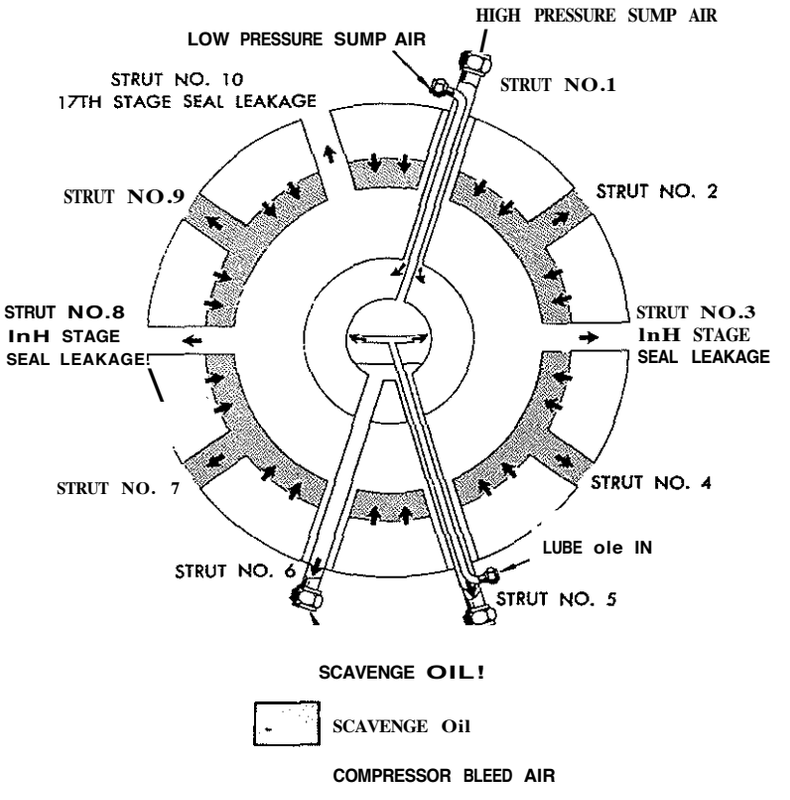
(a) Distortion

(b) Cracks

(5) Fan rotor blades, through exit area (Refer to 72-6-2). Check for cracks in primary airfoil in the two areas defined below by looking **in between the exhaust cone and primary exhaust nozzle.**

(a) An area from midplatform to one inch inboard from midplatform and from trailing edge to 1-1/2 inches forward from trailing **edge.**

(b) An area from dovetail platform to one inch outboard from dovetail platform and from trailing edge to one inch forward from trailing edge.



CJ805-6037-1-C2

Compressor Rear Frame Strut Usage
Figure 3

4. Compressor Rear Stator Casing. The stator rear casing is a machine Chromoloy weldment with 9 stages of fabricated stator vanes. It forms the load-carrying **skin between stator front casing and the compressor rear frame, as well as the support for the rear gearbox and accessories. The stator acts as the rear** structural member of the compressor. All the vanes are fixed, fabricated **airfoils. Between the ninth-stage vane, the second row in this casing, air** vents that allow pressurizing of a manifold on the top stator casing.

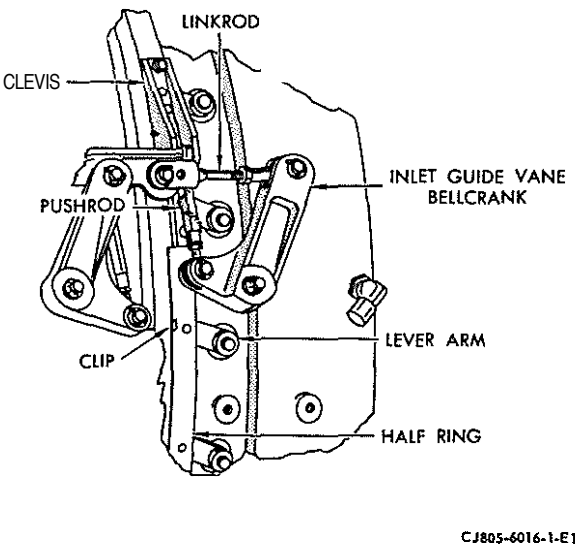
5. Compressor Rotor. The compressor rotor is an all-steel, bolted assembly **consisting** of stub-shafts, discs, blades, ducts, spacers and torque cones. The torque transmission is carried through the rotor by means of the bolted **spacers and torque cones.**

The rotor acts as an axial impeller by compressing the air during rotation. **The rotor also acts' as a passageway for the No. 1 bearing sump pressurizing air, compressor interstage pressurizing air and turbine cooling air. This** air is bled through holes in the seventh-stage spacer.

COMPRESSOR FRONT FRAME ASSEMBLY - MAINTENANCE PRACTICES

1. General. Maintenance of the front frame is limited because it cannot be completely disassembled unless the engine is removed from the aircraft.

2. Removal and Installation. Although the frame cannot be removed from the engine, some items of the frame can be removed.



Inlet Guide Vane Linkage
Figure 201

A. Removal of variable inlet guide vane linkage (figure 201).

(1) Remove the inlet guide vane pushrod by removing the linkpins from both ends.

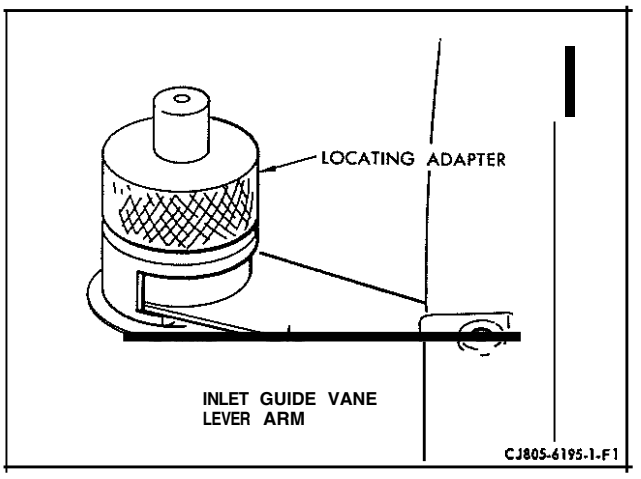
NOTE: Do not disturb the length of the pushrod. Installation is simplified if the length has not been changed.

(2) Remove the inlet guide vane link rod by remOVing linkpins from both ends.

(3) Remove the inlet guide vane bellcrank by removing the nut.

(4) Remove inlet guide vane levers by remOVing the clip and pin from the half-ring and pushing the pin from the outer shaft of the inlet guide vane. Use pin pusher, 2C4365, to remove pin. Remove Teflon washer and spring washer.

B. Installation of variable inlet guide vane linkage (figure 201).



Variable Vane Protractor Adapter Installed
Figure 202

(1) Install the inlet guide vane levers as follows:

(a) Place the spring washer on the vane shaft so that the concave side is facing the frame.

(b) Place a Teflon washer on top of the spring washer.

(c) Position inlet guide vane so that the leading edge is facing forward.

(d) Place the vane lever on the vane shaft so that the pin holes line up when lever is facing aft.

(e) Install the retaining pin through the shaft using pusher, 2C4365.

(f) Secure the vane levers to the half-ring with pins and new clips.

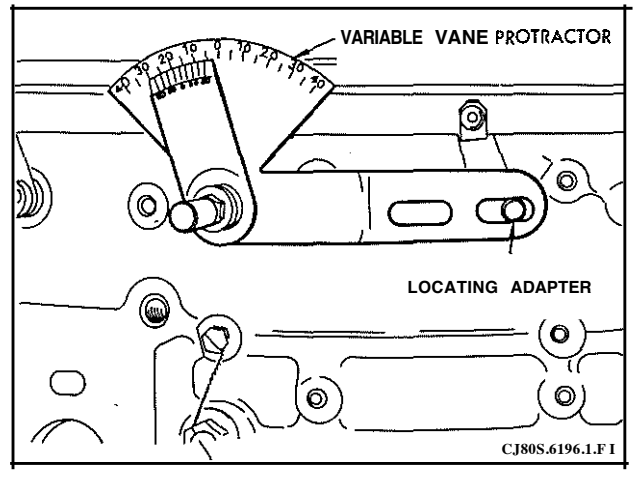
(2) Install the inlet guide vane bellcrank on stud and secure with nut. Torque to 15-30 Ib-in. Install cotterpin.

(3) Install the inlet guide vane pushrod as follows:

NOTE: If the length of the pushrod has not been altered, it may be installed by simply securing both ends with pins. If the length has been changed, but the inlet guide vane position is held by the other pushrod, the length of the pushrod can be adjusted by fitting it between the bellcrank and the half-ring connector. However, if both the pushrods were removed and the lengths changed the following setting procedure must be used.

(a) Install variable vane protractor 2C4338, on inlet guide vane as close to the clevis connector as possible. Install the inlet **guide vane adapter on the second vane from the clevis connector.**

Slide the adapter on the vane from the rear side of the vane and secure in place by threading down the knurled nut (figure 202). Next, place the protractor on the adapter and the vane next to the clevis connector. Slide the adapter of the protractor on to the rear side of the vane; center it with the knurled screw on top of the protractor, and secure in place with the knurled nut under the protractor (figure 203).



Variable Vane Protractor Installed
on Inlet Guide Vane
Figure 203

(b) Install the 2C4338-4 bellcrank locks on each side of the engine as follows: (figure 204)

NOTE: This fixture stabilizes the bellcranks at the basic angle of 64 degrees, 23 minutes. Never attempt to set the vanes unless the bellcranks are stabilized.

- Remove the cotterpins and nuts that hold the 5th and 6th stage bellcranks to support plate pins.

  Install the 2C4338-4P5 bushings onto the pins that secure the bellcranks to the support plate.

- Actuate the variable stators so the lock will fit on the bushings with the semicircular hole over the 5th-stage bushing and the slot in the lock over the 0.250-28 bolt connecting the 6th-stage bellcrank to the master rod.

- Remove the cotterpin and nut securing the 6th-stage bellcrank **to the master rod and set the lock into position.**

  Use the hook and knurled nut on the lock to hold the lock in **position.**

(c) Set the inlet guide vane in an open position so that the protractor reads 33 degrees, 50 minutes ± 15 minutes.

(d) Install the inlet guide vane pushrod by adjusting its length so that the pins can be inserted. Lockwire turnbuckle.

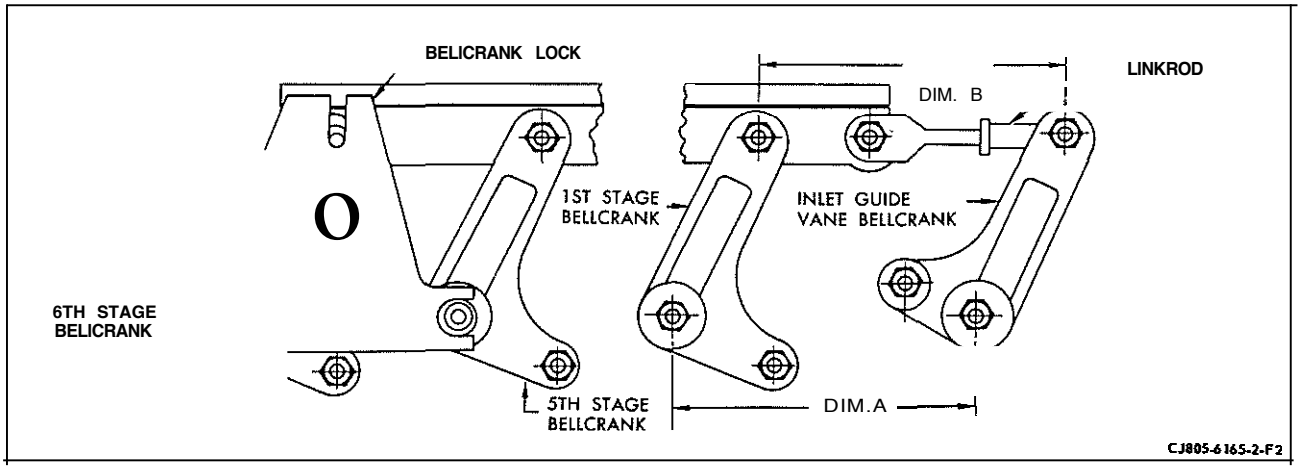
(4) Install inlet guide vane linkrods as follows:

NOTE: If the length of the linkrod has not been altered, it may be installed by simply securing both ends.

(a) Adjust the inlet guide vanes so that the distance A, figure 204, is equal to dimension B, figure 204.

(b) Adjust the length of the linkrod so that it fits the holes of the master rod and bellcrank. Lockwire the turnbuckle of the pushrod.

(c) Secure the pushrods with pins on both ends.



Measuring for Inlet Guide Vane Adjustment
Figure 204

3. Inspection/Checks.

A. Check the inlet guide vane linkage as follows. (See figure 201.)

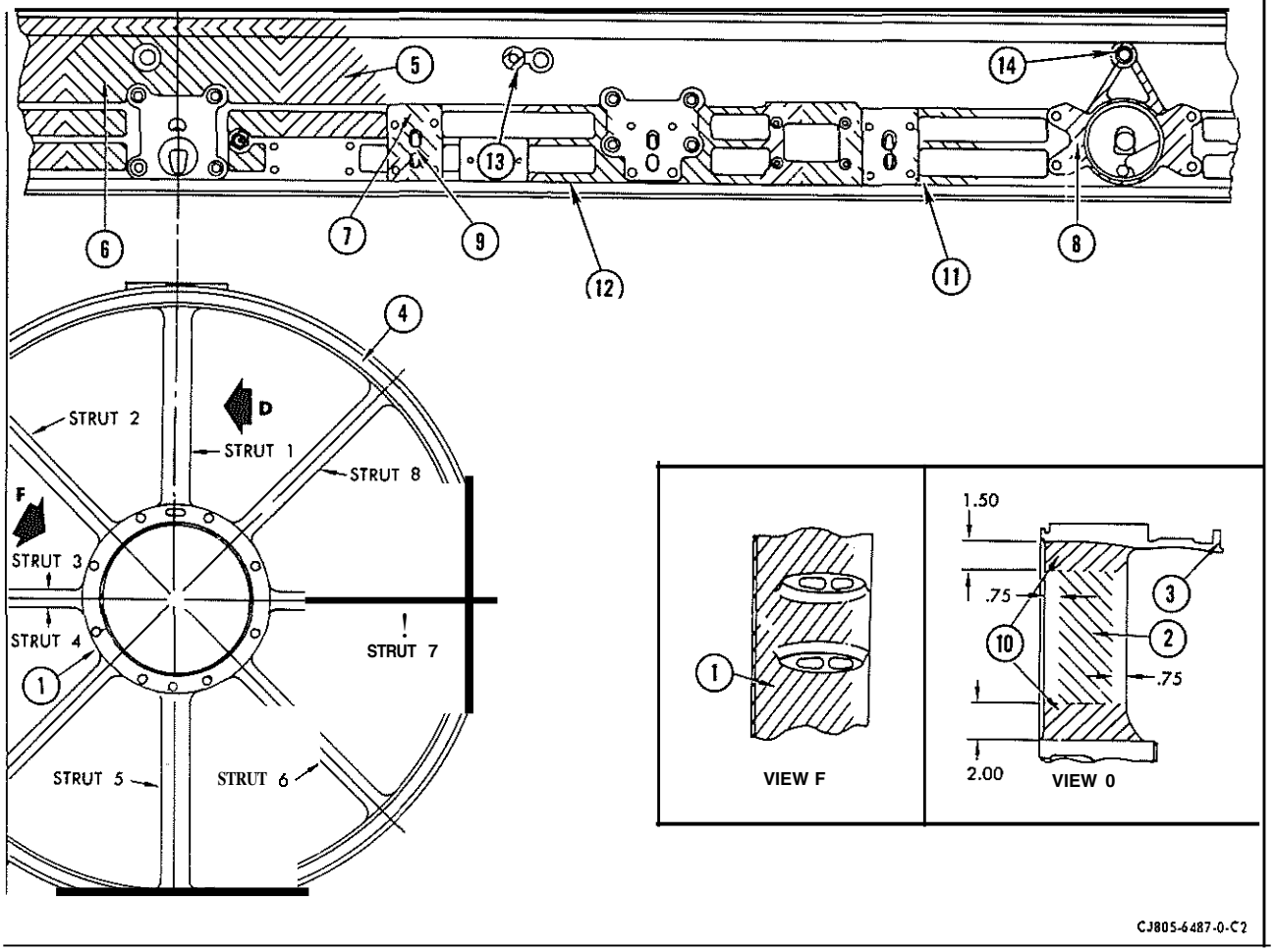
Inspect/Check	Maximum Serviceable Limit	Remarks
(1) Assembled linkage for binding	Not serviceable	Replace affected parts.

Inspect/Check	Maximum Serviceable Limit	Remarks
(2) Bellcranks for:		
(a) Cracks	Not serviceable	
(b) Dents, nicks, pits and scratches	Any number 5/32 inch deep after blending	
(c) Holes for wear	Not serviceable. Teflon lined bushings are serviceable provided parent metal is not exposed	
(3) Pushrod and connecting rod for:		
(a) Distortion	Not serviceable	
(b) Cracks	Not serviceable	
(c) Rod end bearing looseness	Maximum r-ad.LaL movement of 0.015 inch	
(4) Clevis (half-ring connector):		
(a) Cracks	Not serviceable	
(b) Pin holes for wear	Not serviceable	
(c) Bushing looseness	Not serviceable	
(5) Half-rings:		
(a) Cracks	Not serviceable	
(b) Nicks, dents, pits and scratches	Any number, 1/16 inch deep or 1/2 metal thickness after blending	
(c) Bushing looseness	Not serviceable	
(6) Vane levers:		
(a) Cracks	Not serviceable	

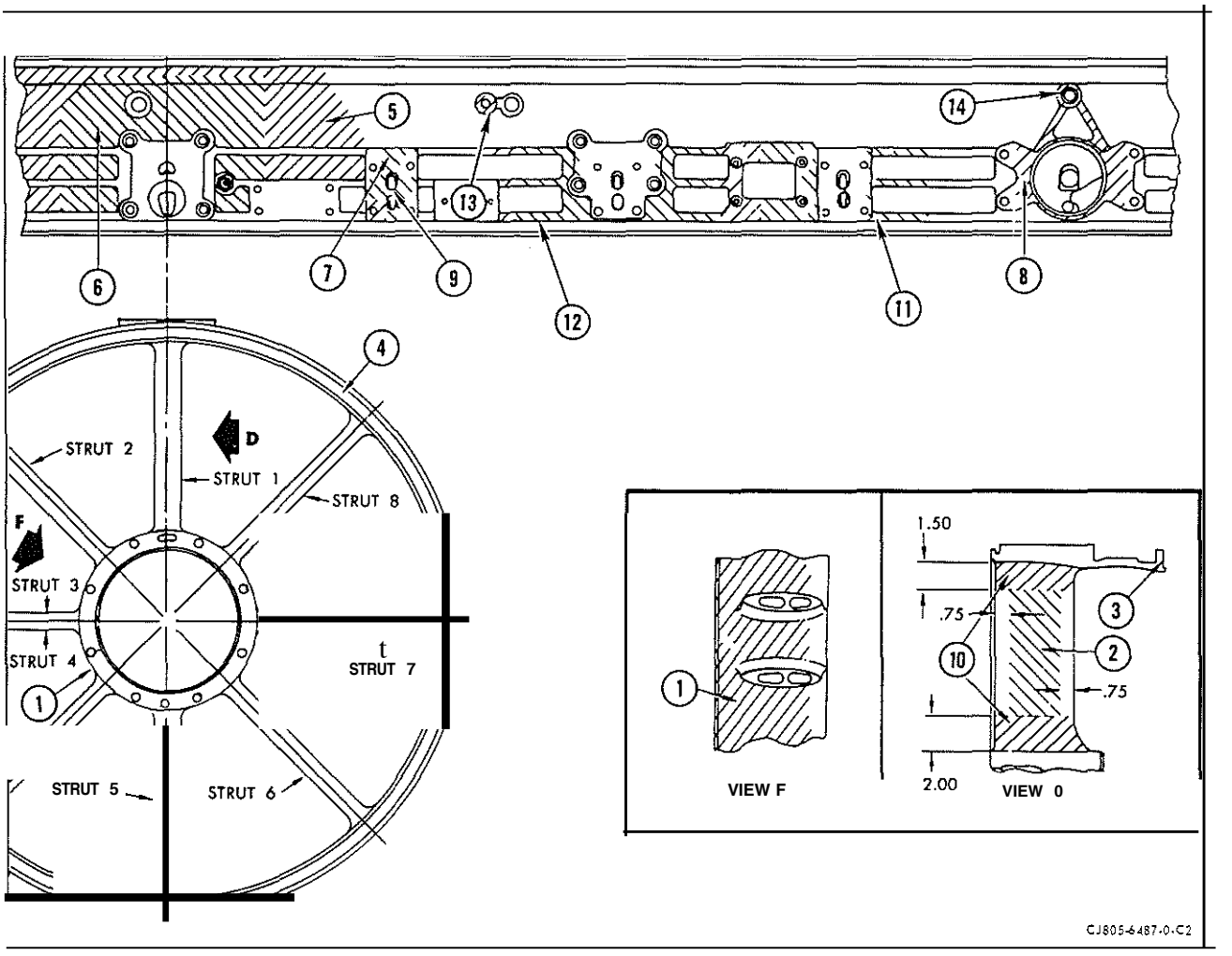
Inspect/Check	Maximum Serviceable Limit	Remarks
(b) Bearing looseness	Maximum radial movement of 0.015 inch	
(c) Nicks, dents, pits and scratches	Any number 1/32 inch deep after blending	

B. Check the front frame as follows. (See figure 205.)

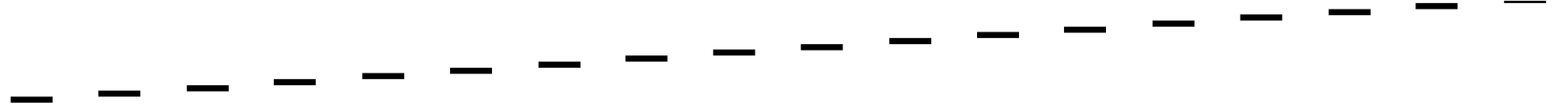
NOTE: If a crack is suspected, confirm by using spot fluorescent-penetrant method of inspection per 89-1-8. Check particulary the areas around the anti-icing bleed holes, the fillets and pad edges of the struts.



Front Frame Inspection
Figure 205



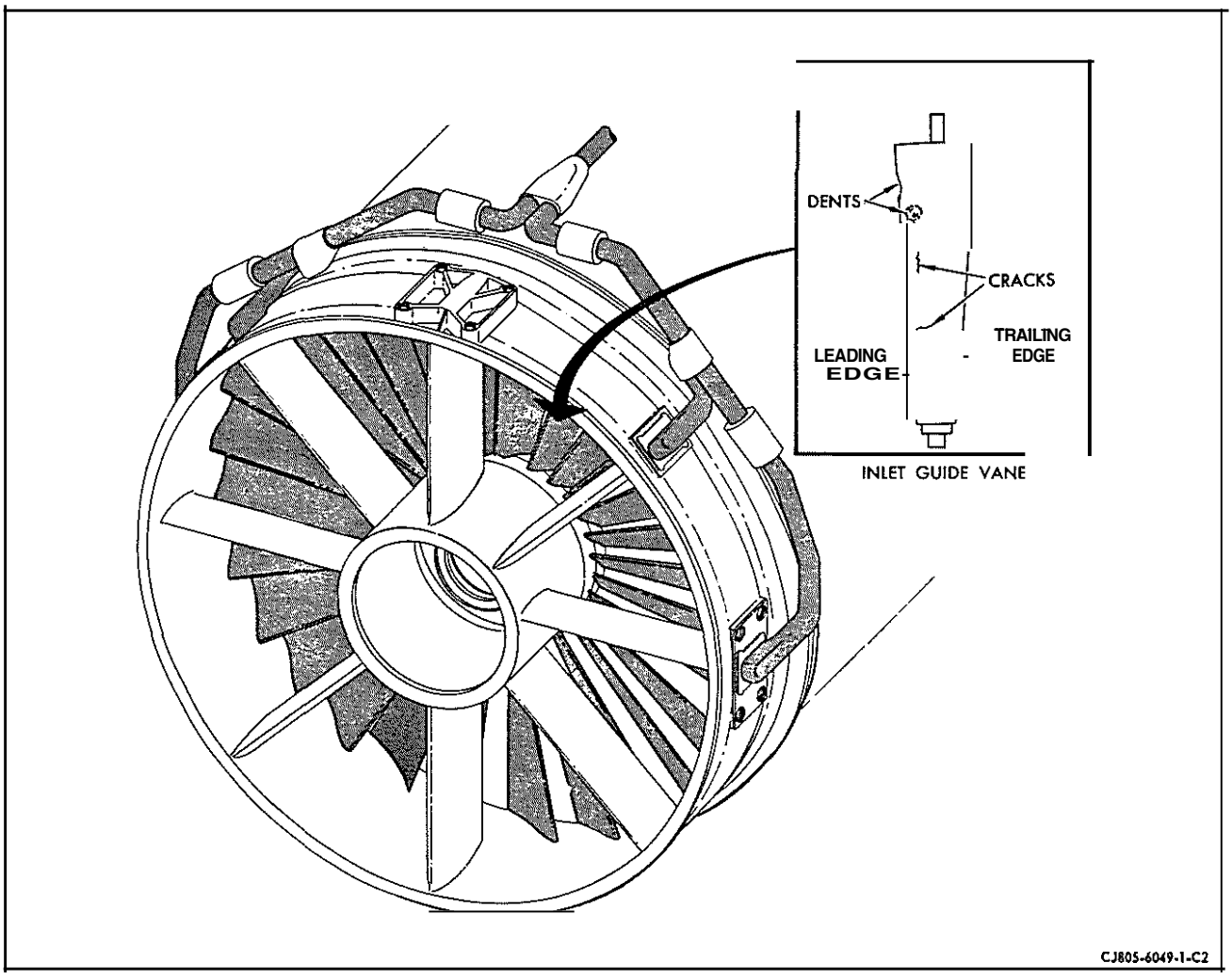
Front Frame Inspection
Figure 205



Inspect/Check	Maximum Serviceable Limit	Remarks
(1) Outer hub of wall (a) for cracks	**8 cracks in any direction,** 1/4 inch long, spaced 3/4 **inch apart, not in strut fillets and no evidence of air or oil leakage**	
(2) Struts for:		
(a) Sides of struts (2) for cracks	30 per frame, 3 per side, 1/2 inch long, spaced 2 **inches apart. No axial** cracks permitted	
(b) Ends of struts (10) for cracks	3 cracks per strut, lis inch long, spaced 1 inch apart. Any number 1/16 inch long, including fillet areas at both ends of strut. No **axial cracks permitted**	
(c) Nicks, scores **and scratches**	Any number 1/32 inch deep after removal of high metal. Any number 3/32 inch deep, not aligned in same plane, after blending	
(3) Front flange (4) for:		
(a) Radial cracks	6 per frame, 1/4 inch long	
(b) Broken areas or **circumferential cracks**	**2 per frame, spaced 6 inches** apart after blending. Blend not to exceed 5/16 inch deep by 1 inch circumferential length	Maintain 1/4 inch **minimum radius at** bottom of blend.
(4) Outer skin and pads at strut ends for:		
NOTE: Treat all bosses, except bellcrank and gearbox bosses, as part of rib when boss forms part of rib. Otherwise, treat as part of skin.		
(a) Cracks in outer skin (5) not **including area within 3 inches** of No. 1 and 5 struts pads	**9 circumferential cracks per** frame, 3/S inch long, spaced 2 inches apart. No axial **cracks allowed**	

Inspect/Check	Maximum Serviceable Limit	Remarks
(b) Cracks in outer skin (6) within 3 inches of No. 1 and 5 strut pads	8 per pad area, any direction, 1/4 inch long, spaced 1 inch apart and 1/2 inch from studs and inserts	
(c) Cracks in strut pads (7) except No. 5 strut pad	4 per pad, any direction, 1/4 inch long, 1/2 inch from inserts, 1/4 inch from connecting rib, spaced 3/4 inch apart	
(d) Cracks in No. 5 strut pad (8)	2 cracks, 1/16 inch long, 1/4 inch from studs, spaced 1 inch apart	
(e) Cracks in rib area (9) between anti-icing hole on struts 2, 3, 7 and 8	Any number, any length provided cracks are only through rib and not into strut wall	
(f) Cracks in rib and rib fillets (11) within 1/4 inch of strut pads	5 per pad, 2 per rib end any direction, 1/8 inch long. No axial cracks permitted at struts No. 1 and 5	
(g) Cracks in rib and rib fillets (12) beyond 1/4 inch from strut pads	5 per rib section between strut pads, 1/4 inch long, spaced 3/4 inch apart	
(h) Cracks in strut pad fillets	4 per pad any direction, 3/8 inch long. No axial cracks permitted on struts No.1 and 5	
(i) Cracks in bell-crank bosses (13) including fillets	2 circumferential cracks per boss, 1/8 inch long, 1/2 inch from insert. 2 longitudinal cracks per boss, 1/4 inch long, 1/4 inch from inserts	

Inspect/Check	Maximum Serviceable Limit	Remarks
(j) Cracks in transfer gearbox boss (14) including fillet	2 cracks, any direction, 1/8 inch long, 1/2 inch from insert. Any number, any direction, 1/16 inch long within 1/2 inch of insert	
(k) All unmachined area for nicks, scores and scratches	Any number 3/32 inch deep after removal of high metal	
(l) Studs and inserts for looseness	Not serviceable	



Inspection/Check of Front Frame
Figure 206

Inspect/Check	Maximum Serviceable Limit	Remarks
C. Check the inlet guide vanes as follows. (See figure 206.)		
(1) Nicks, pits or scratches	Any number, 0.020 inch deep	
(2) Dents on body and leading edge	2 per vane, 3/32 inch deep provided an abrupt change in contour does not exist	
(3) Dents on trailing edge	2 per vane, 5/32 inch deep provided an abrupt change in contour does not exist	
(4) All areas for cracks	Not serviceable	
(5) Warping or ballooning	Not to exceed 3/16 inch throughout the length of vane	

4. Approved Repairs.

A. Remove high metal from nicks and scratches, using a fine file or crocus cloth. Treat repaired area of front frame casting with dichromate.

NOTE: The protective coating of black enamel need not be replaced; however, the operator may do so if he desires.

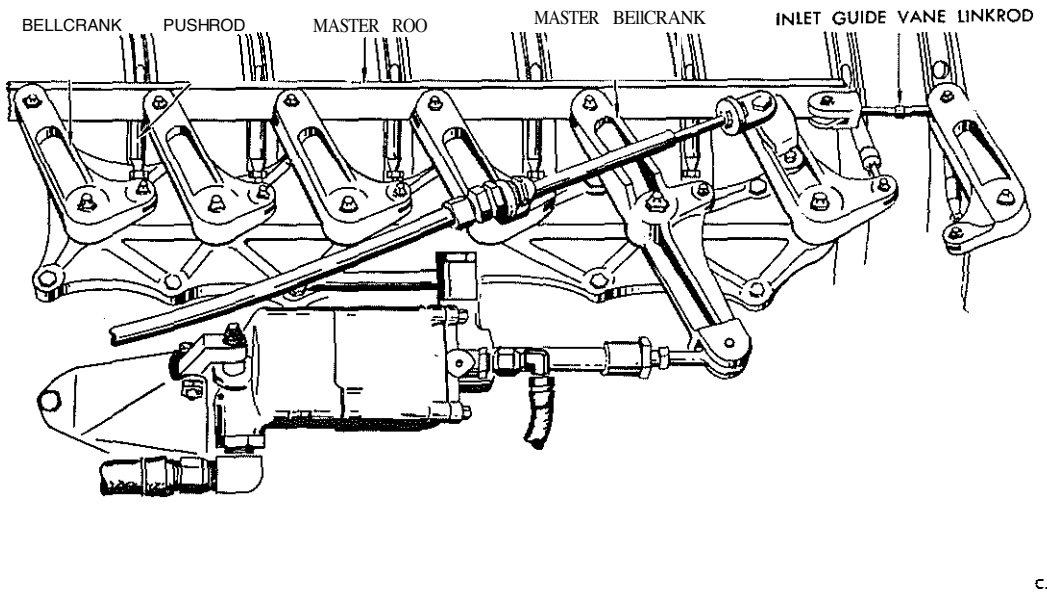
B. Replace parts that are replaceable when they are beyond limits. Replace engine when damaged part cannot be replaced.

C. Replace damaged or loose inserts or studs. Refer to section 89-1-3.

COMPRESSOR FRONT STATOR CASING - MAINTENANCE PRACTICES

1. General. The maintenance that can be performed on the front stator is limited to those external items that are accessible through the engine inlet.

2. Removal and Installation. The only external removable items are those comprising the variable vane linkage.



Variable Vane Linkage
Figure 201

A. Removal of variable stator vane linkage. (See figure 201.)

(1) Remove the variable vane pushrods by removing the pins from the connector and bellcrank.

NOTE: Do not disturb the length of the pushrod. Installation is simplified if the length has not been changed.

(2) Remove the bellcranks by disconnecting from the pushrods and master rod and removing the nut securing the bellcrank to the support plate.

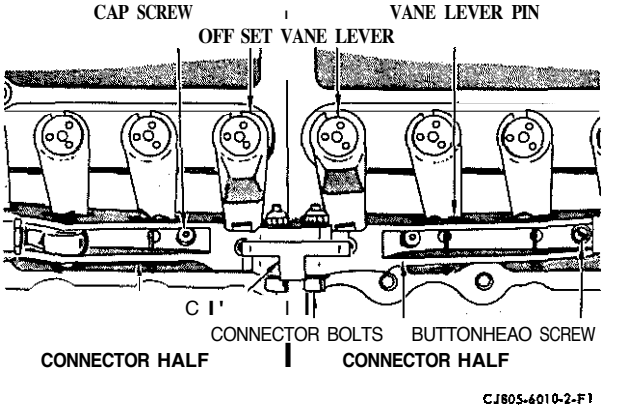
NOTE: The master bellcrank must be disconnected from actuator.

(3) Remove master rod by removing the pins that secure it to the bellcranks and inlet guide vane linkrod.

(4) Remove the vane levers from the vanes by removing the clips and pins from the half-ring and the nut securing the lever to the vane. Remove spacer and Teflon bushing.

CAUTION: DO NOT REMOVE THE VANE LEVERS FROM FIFTH- AND SIXTH-STAGE VANES. DOING SO WILL ALLOW THE VANE TO SLIP INWARD AND RISK DAMAGING THE TEFLON BUSHING ON ASSEMBLY.

(5) Remove the half-rings as follows:



Variable Vane Half-Ring Connector
Figure 202

(a) Remove the clips and pins from the vane levers (figure 202).

(b) Remove the bolts connecting the halves of the bridge connectors.

NOTE: This will free the locking clip for the two pins holding **the two extended vane levers in place.**

(c) Remove the bridge connector by removing button and cap screws (figure 202).

NOTE: The bridge connectors are matched pairs and must be kept together.

(d) Slip the half-ring forward and off the vane levers. Keep half-**rings with their respective connectors.**

B. **Installation of variable stator vane linkage:**

(1) Install half-ring without connector pin retention modification as follows:

(a) Position all the vane levers so they are facing forward.

(b) Install bridge connector halves on the half-ring.

NOTE: Make certain the bridge connectors match their respective halves.

(c) Slide the half-ring onto the vane levers and secure them all with pins and new clips.

(d) Install the bolts that secure the bridge connectors.

NOTE: Make certain the pin retainer is installed at this time.

(1a) Install half-ring with connector pin retention modification as follows:

(a) Position all vane levers so they are facing forward.

(b) Slide the half-rings onto the vane levers and secure with pins and new clips.

(c) Install bridge connector halves on the half-rings.

NOTE: Make certain the bridge connectors match their respective halves.

(d) Install all the bolts that secure the bridge connectors.

(2) Install vane levers on stages 1 through 4 as follows:

(a) Install the spacer on the vane.

(b) Install a Teflon bushing on top of the spacer.

(c) Install the spacer on the vane.

(d) Slide the vane lever onto the half-ring and onto the vane.

(e) Install the vane nut. Torque nuts to 70 in. lb.

NOTE: Make certain the tang on the vane is properly engaged in the vane lever and is protruding above it at least 0.006 inch. After torquing the nut, rotate the blade back and forth with a torque wrench. Maximum torque required to turn vane is 3 lb. in.

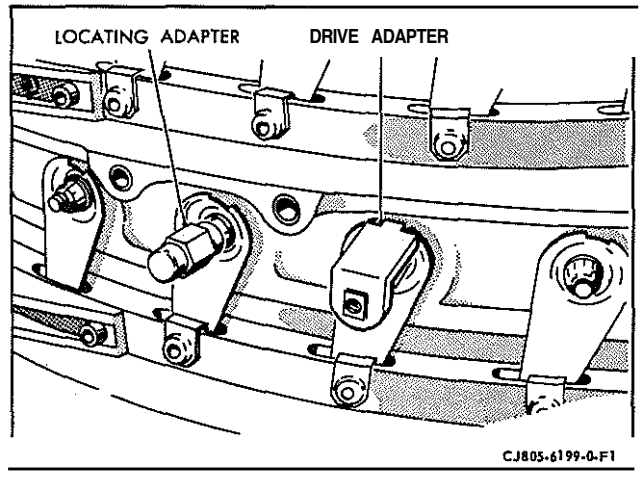
(3) Install the master rod by connecting it to the bellcranks and inlet guide vane pushrod..

(4) Install the bellcranks by securing them to the support plate with nut. Tighten the nut all the way down, then back off 1/4 turn. Connect the pushrod and master rod.

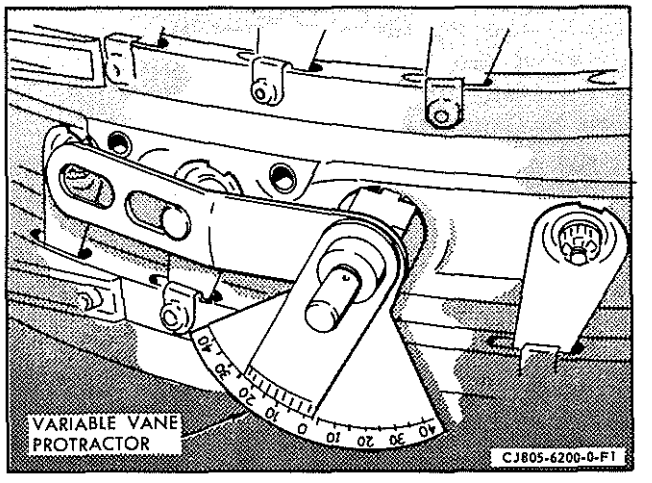
(5) Install the variable stator vane pushrods as follows:

NOTE: If the length of the pushrod has not been altered it may be installed by simply securing both ends with pins. If the length has been changed, but the variable vane position held by the other pushrod, the length of the pushrod can be adjusted by fitting it between the bellcrank and the half-ring **connector. However, if both the pushrods were removed and** the length changed, the following setting procedure must be **used.**

(a) Install the variable vane protractor, 2C4338, on a variable vane as close as possible to the bridge connector. Screw a locating adapter (-9 for stages 1 through 4 and -3 for stages 5 and 6) on a vane shaft next to the bridge connector. Install a drive adapter (-2Gl for stages 1 and 2, -2G2 for stages 3 and 4, and -2G3 for stages 5 and 6) on the second vane from the bridge connector. Make certain the tab on the drive adapter is aligned with the slot in the vane lever before screwing the adapter on the vane shaft. Use an Allen-head wrench in the center of the drive adapter to screw the adapter on the vane shaft (figure 203). Place the protractor on the adapters so the gage end is on the drive adapter. Secure the protractor in place with the knurled nut on the gage end (figure 204).



Variable Vane Adapters Installed
Figure 203

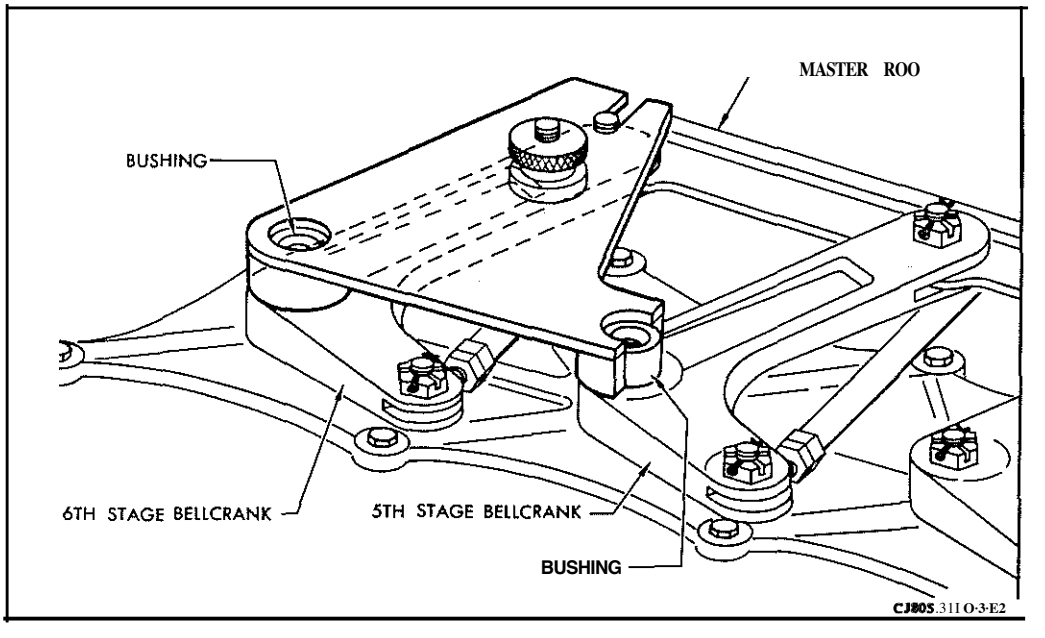


Variable Vane Angle Setting Gage Installed
Figure 204

(b) Install the 2C4338-4 bellcrank locks on each side of the engine as follows: (figure 205)

NOTE: This fixture stabilizes the bellcranks at the basic angle of 64 degrees, 23 minutes. Never attempt to set the **vanes unless the bellcranks are stabilized..**

1. Remove the cotterpins and nuts that hold the 5th and 6th stage bellcranks to support plate pins.



Bellcrank Lock Installed
Figure 205

2. Install the 2C4338-4P5 bushings onto the pins that secure the bellcranks to the support plate•

3. Actuate the variable stators so the lock will fit on the bushings with the semicircular hole over the 5th stage bushing and the slot in the lock over the 0.250-28 bolt connecting the 6th stage bellcrank to the master rod•

4. Remove the cotterpin and nut securing the 6th stage bellcrank to the master rod and set the lock into position.

5. Use the hook and knurled nut on the lock to hold the lock in position.

(c) Set the variable vanes of each stage in an open position so the protractor reads the correct angle for the stage involved.

Stage	Angle
1st	25 **degrees,** 0 **minutes** ± 15 **minutes**
2nd	24 **degrees,** 0 **minutes** ± 15 **minutes**
3rd	18 **degrees,** 0 **minutes** ± 15 **minutes**
4th	18 **degrees,** 0 **minutes** ± 15 **minutes**
5th	18 **degrees,** 0 **minutes** ± 15 **minutes**
6th	22 **degrees,** 45 minutes ± 15 minutes

(d) Install the pushrod between the bridge connector and bellcrank by adjusting its length so that the pins can be inserted. Lock-**wire turnbuckle.**

3. Inspection/Check.

A. Check the variable stator vane linkage as follows:

Inspect/Check	Maximum Serviceable Limit	Remarks
(1) Assembled linkage for binding	Not serviceable	Replace affected parts.

Inspect/Check	Maximum Serviceable Limit	Remarks
(2) Bellcranks for:		
(a) Cracks	**Not serviceable**	
(b) Dents, pits and scratches	Any number 5/32 inch deep after blending	
(c) Holes for wear	Not serviceable. Teflon lined bushings are serviceable provided parent metal is not exposed	
(3) Main Crank for:		
(a) Cracks	Not serviceable	
(b) Dents, pits and scratches	Any number 3/32 inch deep after blending	
(c) Holes for wear	Not serviceable. Teflon lined bushings are serviceable provided parent metal is not exposed	
(4) Pushrods for:		
(a) Distortion	**Not serviceable**	
(b) Cracks	**Not serviceable**	
(c) Rod end bearing looseness	Maximum radial movement of 0.015 inch	
(5) Master Rod for:		
(a) Cracks	Not serviceable	
(b) Dents, nicks, pits and scratches	Any number 5/32 inch deep after blending	
(c) Bearing for looseness	Maximum radial movement of 0.015 inch	

Inspect/Check	Maximum Serviceable Limit	Remarks
(d) Bushings for **wear**	Maximum of 5/16 inch diameter for sintered iron bushings. Teflon lined bushings are serviceable provided parent metal is not exposed	
(6) Bridge (half-ring) **connectors for:**		
(a) Cracks	Not serviceable	
(b) Holes for wear	Not serviceable	
(c) Bushings for **looseness**	Not serviceable	
(7) Half-Rings for:		
(a) Cracks	Not serviceable	
(b) Dents, nicks, pits and scratches	Any number 1/16 inch deep or 1/2 the metal thickness after blending	
(c) Bushings for **looseness**	Not serviceable	
(8) Clips for bent, cracked or distorted	Not serviceable	
(9) Pins for:		
(a) Wear	Not serviceable	
(b) Missing	Not serviceable	Return engine to overhaul
(10) Vane lever locknuts free running torque	Minimum of 7 lb-in.	
(11) Vane levers for:		
(a) Cracks	Not serviceable	
(b) Bearing for **looseness**	Maximum radial movement of 0.015 inch	
(c) Nicks, dents, pits and scratches	Any number 1/32 inch deep after blending	

Inspect/Check	Maximum Serviceable Limit	Remarks
(12) Teflon bushings for wear, tears or cracks	Not serviceable	Replace damaged bushings in stages 1 through 4.

NOTE: The 5th and 6th-stage bushings cannot be replaced as the vanes are not shrouded on the ID.

(13) Vane tang engagement into lever arm notch	Tang must be completely inside the notch and extend a minimum of 0.006 inch above top of lever arm	

B. Check the external surface of the front compressor stator casing for:

(1) Nicks, gouges and scratches	Any number 0.020 inch deep. On bosses and ribs, any number 1/32 inch deep	
(2) Cracks	Not serviceable	
(3) Pits	Any number lis inch in diameter 0.020 inch deep. Pits within 1-1/2 inches of flanges must be spaced 1 inch apart	

C. Check the stator vanes for:

NOTE: This inspection is made by looking through the engine inlet.

(1) Cracks	Not serviceable	
(2) General damage (peppering)	Any amount, up to 1/32 inch deep provid.ed vane is not torn, damage does not break through and vane is not distorted	
(3) Damage beyond 1/32 inch deep	Any amount provided damage does not form a line transverse to airfoil that will crack in subsequent operation; damage is 1/2 inch from leading or trailing edge; damage does not break through (protrusion is acceptable); damage is less than 0.100 inch in diameter	

Inspect/Check	Maximum Serviceable Limit	Remarks
(4) Leading and trailing edge damage	JUdge acceptability by the sharpness of the damage	Repair sharp edges by blending per paragraph 4.

4. Approved Repairs.

A. Remove high metal from nicks, gouges and scratches by using a fine file or crocus clotho

B. Replace parts that are replaceable, when beyond limits. Replace engine when parts cannot be replaced.

C. Vane leading and trailing edge repair may be accomplished by blending per 89-1-3 provided the blend is no deeper than 1/16 inch and no blending is performed in the outer 1/4 of the vane. All blends must be a minimum of 1/2 inch in length.

COMPRESSOR STATOR REAR CASING - MAINTENANCE PRACTICES

1. General. The maintenance of this casing is limited to the external section. The removal of this casing can be accomplished only when the engine is removed from the aircraft.

2. Inspection/Check.

Inspect/Check	Maximum Serviceable Limit	Remarks
A. Check the following areas for nicks and scratches:		
(1) Vertical and horizontal flanges, ribs and ninth-stage manifold	Any number, 1/32 inch deep, spaced 1 inch apart. Scratches not exceed 1 inch in length	
(2) Skin area	Any number 1/32 inch deep	
B. Check the following areas for cracks in welds:		
(1) Air extraction pad, bosses and horizontal flange weld	1 crack per area, 1/4 inch long	
(2) Ninth-stage manifold	2 cracks, 1/4 inch long, separated by 12 inches of unaffected material	
(3) Gearbox bracket weld	Not serviceable	
C. Cracks in parent metal	Not serviceable	
D. All areas for pits	Any number, 1/32 inch deep	
E. Distortion or bulges to casing	Not serviceable	

3. Approved Repairs.

A. Remove high metal from nicks and scratches.

B. Replace engine when casing is damaged beyond limits.

COMPRESSOR ROTOR - MAINTENANCE PRACTICES

1. General. The maintenance of the compressor rotor is limited to those items that can be reached through the inlet of the engine; namely first-stage compressor rotor blades.

NOTE: For best visibility of the compressor rotor blades open the inlet guide vanes. Use hydraulic cart, 2C4006, or a hand pump, on the variable vane actuators and pump the vanes to an open position.

Figure 201 DELETED.

2. Inspection/Check.

Inspect/Check	Maximum Serviceable Limit	Remarks
A. Inspect rotor blades for:		
(1) Cracks	Not serviceable	
(2) General damage (peppering)	Any amount up to 1/64 inch deep provided. vane is not torn, damage does not break through and vane is not distorted	
(3) Damage beyond 1/64 inch deep	Any amount provided damage does not form a line transverse to airfoil that will crack in subsequent operation; damage is 1/2 inch from leading or trailing edge; damage does not break through (protrusion is acceptable); damage is less than 0.075 inch in diameter	
(4) Leading and trailing edge damage	JUdge acceptability by the sharpness of the damage	Repair sharp edges by blending per paragraph 4.
(5) Tip curl	Any amount provided it does not engage stationary parts during operation and there is no other blade distortion caused by the damage	

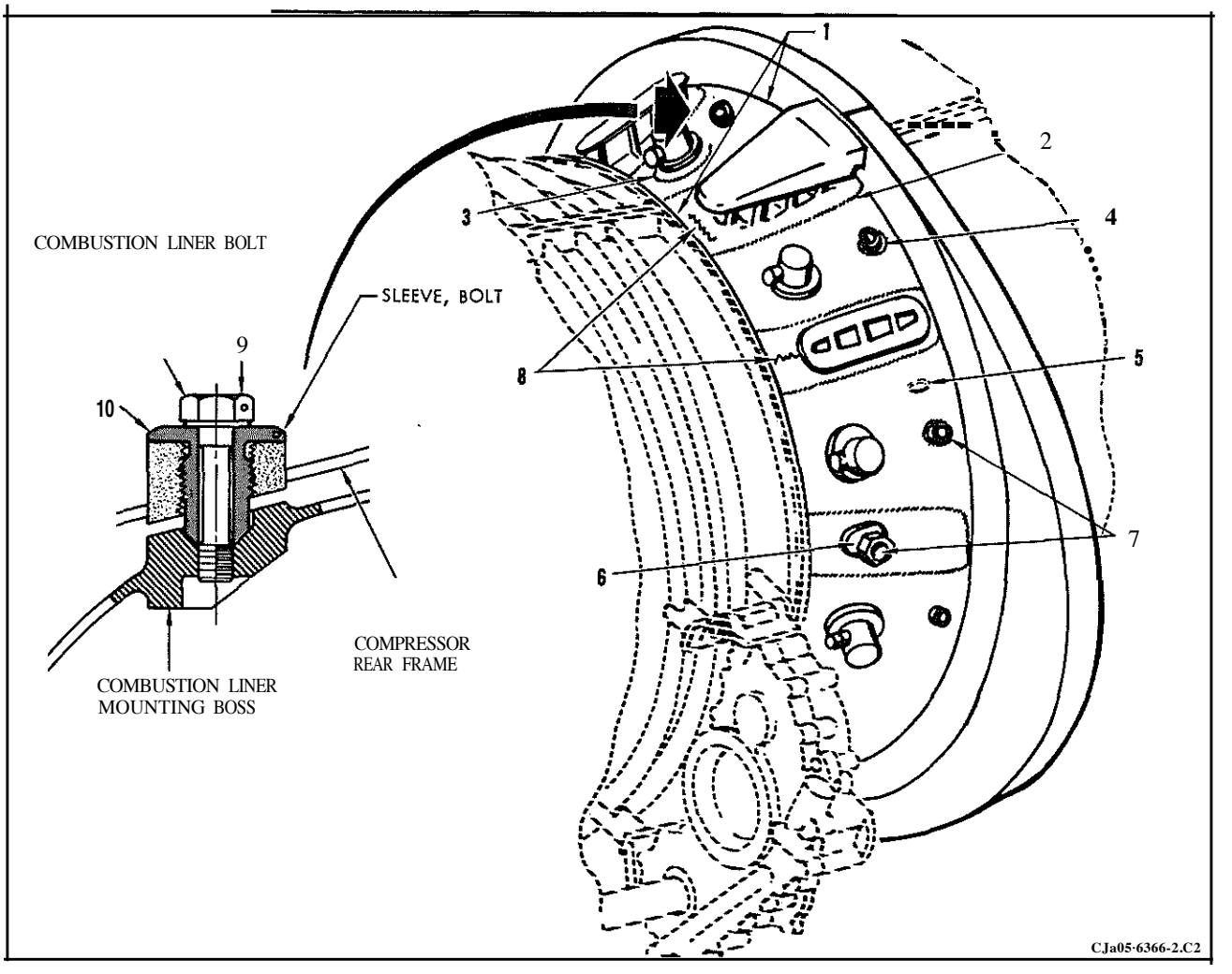
3. Approved Repair. Replace the engine if the serviceable limits are exceeded.

A. Damage on the leading and trailing edge of the stage 1 blades that require blending should be blended per 89-1-3. Blend may be a maximum of 1/8 inch deep. provided there was no previous rework on either edge. If either edge was previously blended do not rework the chord length below 2.084 inches minimum. No blending is permitted within 1-1/4 inch of the base of the blade. All blends must be a minimum of 1 inch in length.

B. Replace the engine if the serviceable or repairable limits are exceeded.

COMPRESSOR REAR FRAME - MAINTENANCE PRACTICES

1. General. The maintenance of the rear frame is limited to the external portion. **Those items that are accessible are covered in this section•**



Compressor Rear Frame Damage Check
Figure 201

2. Inspection/Check. (See figure 201.)

Inspect/Check	Maximum Serviceable Limit	Remarks
A. Check the following areas for cracks:		
(1) Front and rear flange welds (1)	**Not serviceable**	

Inspect/Check	Maximum Serviceable Limit	Remarks
(2) Support gusset welds at extraction and leakage port (2)	**Not serviceable**	
(3) Fuel nozzle port weld (3)	Not serviceable	
(4) External boss welds (4)	1 per boss, 1/4 inch long	
(5) Skin for cracks	Not serviceable	
(6) Firewall panels	Any number, 1/4 inch long	
(7) Outer strut supports for: (8, figure 201)		
(a) Axial cracks	1 inch at either end of strut	
(b) **Circumferential cracks**	2 inches at either end of **strut. No two cracks, in any direction, at anyone** strut is allowable. Maximum of 3 cracked strut supports per frame	
B. Dents in skin (5)	Any number, 5/16 inch deep, provided diameter is 6 times the depth	
C. Struts No. 5 and 6 for oil leakage around slip joint of the tubes	Not serviceable	
D. Tube sleeve bushing (struts No. 5 and 6) for wear (6)	Wear can only be in a 180 **degree sector to a maximum** of 0.045 inch in depth. Burnishing of 0.010 inch in depth is acceptable on opposite 180 degree	
E. Combustion liner bolt (9) for looseness	**Not serviceable**	Remove bolt and sleeve bolt. **Inspect combustion** liner boss threads **and if serviceable,** replace bolt. Torque to 110-139 lb-in. and lockwire. If liner threads are damaged replace **engine**

CAUTION: A BOLT THAT IS REMOVED MUST BE REPLACED BEFORE ANOTHER BOLT IS REMOVED.

Inspect/Check	Maximum Serviceable Limit	Remarks
F. Combustion liner sleeve bolt (10) **for looseness**	**Not serviceable**	Remove bolt and sleeve bolt. **Inspect rear frame** boss threads per paragraph H, and **if serviceable, replace sleeve** bolt. Torque to 90-100 lb-in. and **lockwire. If frame threads are damaged, replace engine.**

CAUTION: A BOLT THAT IS REMOVED MUST BE REPLACED BEFORE ANOTHER BOLT IS REMOVED.

G. External boss and coupling nut (7) for thread wear (except combustion liner boss)	Cumulative length of 1 full **thread may be missing**	
H. Combustion liner boss thread weal' (check when sleeve bolt is removed)	Must not accept a 0.500-20-UNF-2B "No-Go" plug gage	
I. Nicks, dents, scratches and gouges in leakage ports and firewall **panels**	Any amount provided damage is not completely through	

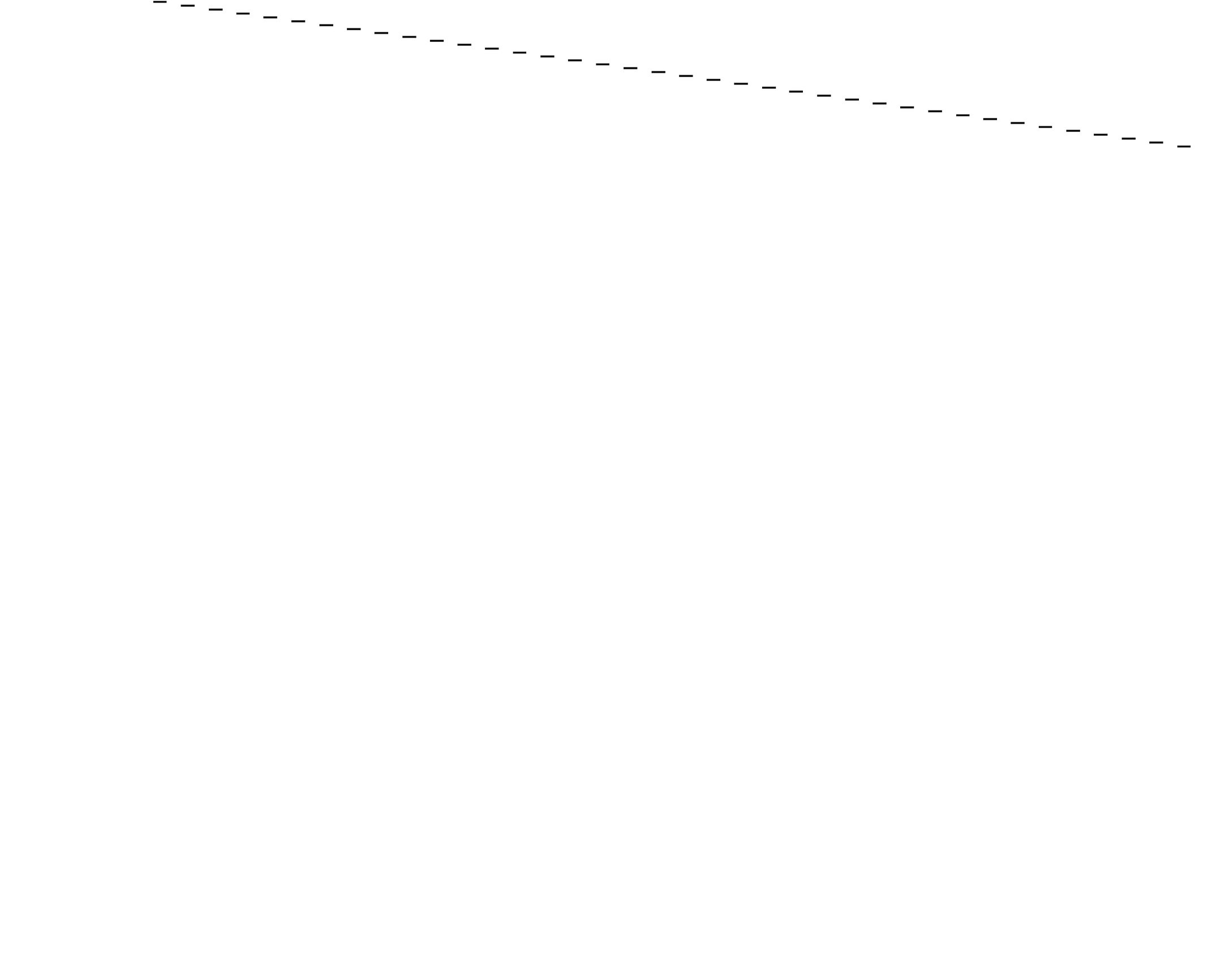
3. Approved Repair. Replace engine when serviceable limits are exceeded.

Inspect/Check	Maximum Serviceable Limit	Remarks
F. Combustion liner sleeve bolt (10) for looseness	Not serviceable	Remove bolt and sleeve bolt. Inspect rear frame boss threads per paragraph H, and if serviceable, replace sleeve bolt. Torque to 90-100 lb-in. and lockwire. If frame threads are damaged, replace engine.

CAUTION: A BOLT THAT IS REMOVED MUST BE REPLACED BEFORE ANOTHER BOLT IS REMOVED.

G. External boss and coupling nut (7) for thread wear (except combustion liner boss)	Cumulative length of 1 full thread may be missing	
H. Combustion liner boss thread wear (check when sleeve bolt is removed)	Must not accept a 0.500-20-UNF-28 "No-Go" plug gage	
I. Nicks, dents, scratches and gouges in leakage ports and firewall panels	Any amount provided damage is not completely through	

3. Approved Repair. Replace engine when serviceable limits are exceeded.



COMBUSTION SECTION - DESCRIPTION AND OPERATION

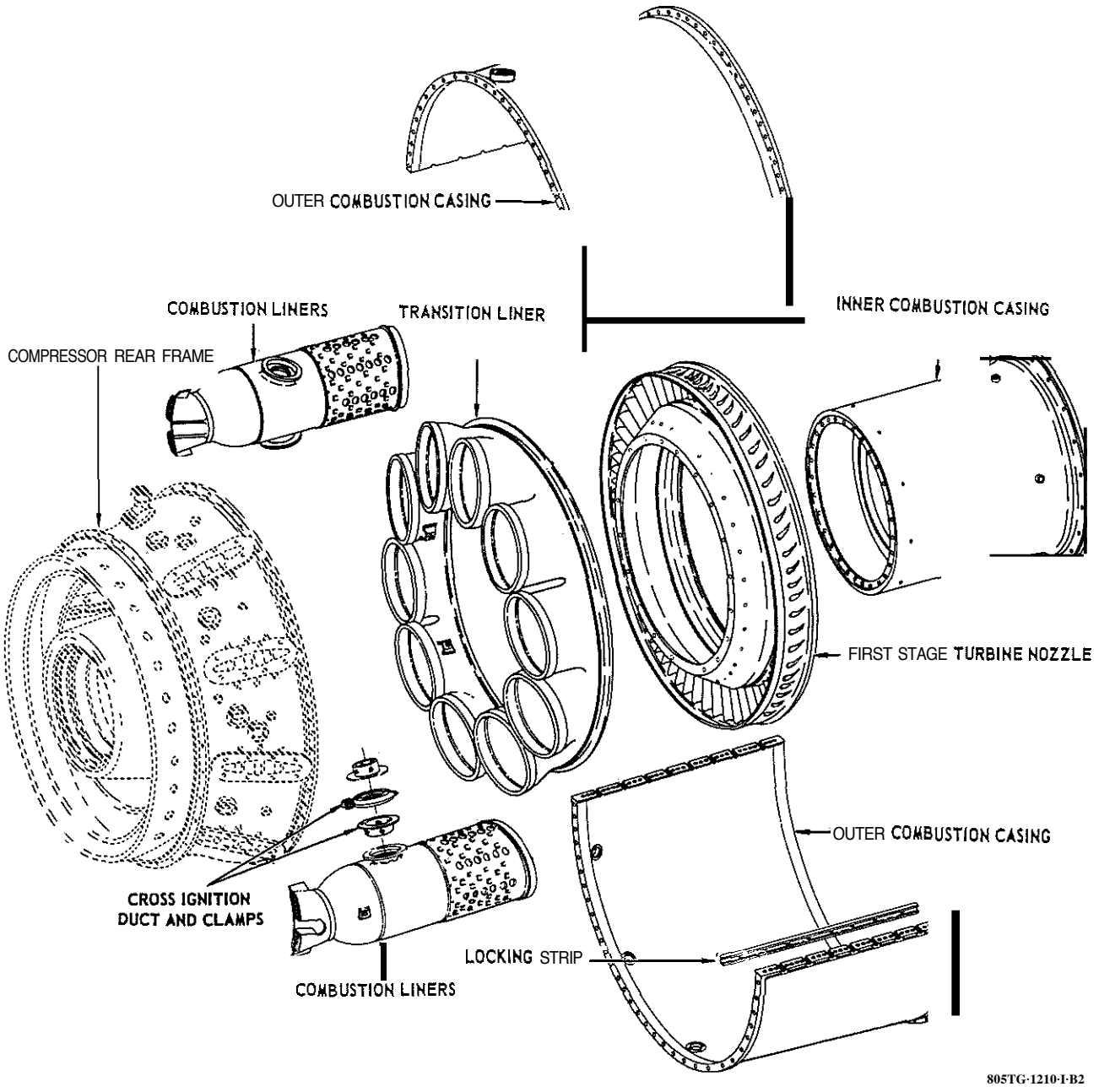
1. General. (See Fig. 1.) **The combustion section of the engine consists of the outer combustion casing, the combustion liners, cross ignition tubes and clamps, transition duct, inner combustion casing and the first-stage turbine nozzle.**

   A. Outer Combustion Casing Assembly. The outer combustion casing is a sheet metal cylindrical-shaped component. The locking strip seals the horizontal flanges and reduces hoop stress on the flange bolts, permitting the use of smaller bolts and lighter flanges. The forward flange of the outer combustion casing is bolted to the rear flange of the compressor rear frame; the rear flange is bolted to the front flange of the turbine stator casing, which forms the load carrying outer skin between the compressor rear frame and the turbine stator casing. The outer combustion casing provides the outer skin for the annular passage, which contains the combustion liners where the combustion of the fuel and air mixture takes place.

   B. Combustion Liners. The combustion liner is a 3-piece riveted assembly. The combustion liners are located within the annular passage formed by the outer combustion casing and the inner combustion casing. The combustion liners, supported at their aft ends by the transition duct, are mutually self supporting at their forward ends because of clamps that secure the cross-ignition eyelet flanges. Each liner has a boss welded to the cowl, which engages a removable support bolt located in the compressor rear frame.

   C. Cross-Ignition Tubes and Clamps. The cross-ignition tubes provide a duct for passage of flame from one combustion liner to the other. They are provided with louvers, which pick up cooling air from between the inner and outer combustion liner. The cross-ignition clamps are bolted hinge clamps and structurally join all of the combustion liners together at the cross-ignition eyelet flanges. Two cross-ignition ducts are sandwiched between these flanges.

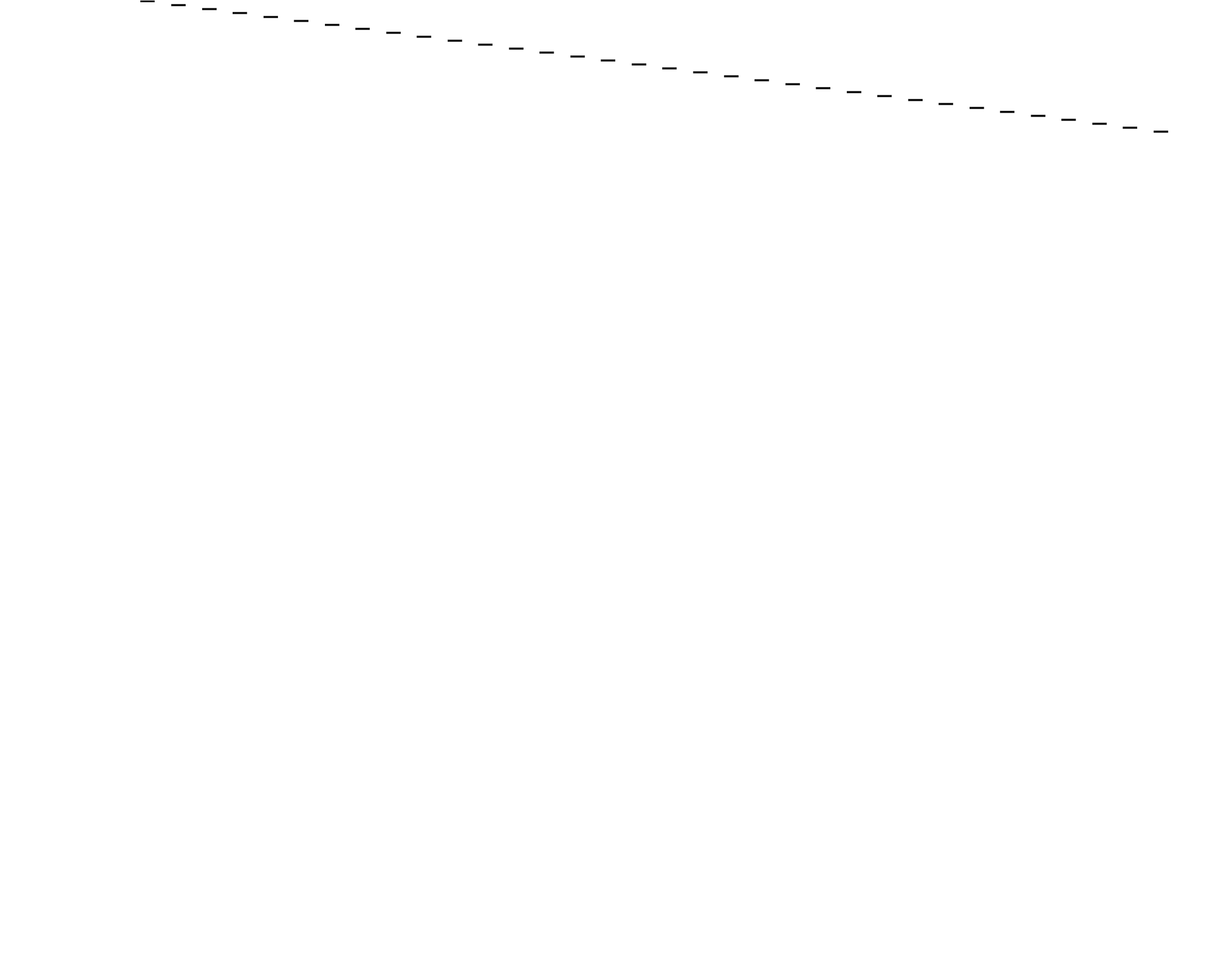
   D. Transition Duct. The transition duct assembly is fabricated in such a manner as to form a ring with 10 circular openings at the upstream or entrance end. The combustion liners slip into these openings during the assembly of the combustion assembly, and their aft ends are thus supported. The downstream end of the transition duct has a annular passage with a cross-section area approximately equal to the total cross-sectional area of the 10 circular openings on the upstream end. The transition duct provides a smooth transition of engine air flow from a circular passage to an annular passage so that entrance velocity and pressure at the first-stage nozzle diaphragm will be uniform.



Combustion Section
Figure 1

E. Inner Combustion Casing. The inner combustion casing is a supporting structure for the combustion section. It also forms the inner wall of the air passage through the combustion section. Three stiffener rings are welded to the inner surface. A flange is bolted to the compressor rear frame inner diffuser: the first-stage turbine nozzle is bolted to the rear flange. Five pin bosses are located around the rear portion of the casing. A pin bolt is threaded into the casing, and when pinned to the transition liner it provides the radial support for the liner.

F. First-Stage Turbine Nozzle. The first-stage turbine nozzle directs the gas stream from the transition liner so that the gases strike the first-stage turbine buckets at the proper angle for maximum power extraction. The turbine nozzle is a sheet metal fabrication consisting of an inner and outer band, partitions, baffles and the rear half of an air seal. The mounting flange on the forward side of the assembly is bolted to the forward side of the flange on the aft end of the inner combustion casing. Slip-type flanges on the front and rear side of the nozzle mate with flanges on the aft end of the transition liner and the forward end of the first-stage turbine shroud.



OUTER COMBUSTION CASING - MAINTENANCE PRACTICES

1. **General.** The maintenance of the outer combustion casing usually involves only the external area of the casing.

2. Inspection/Checks of Casing. Visually inspect the outer combustion casing for the following:

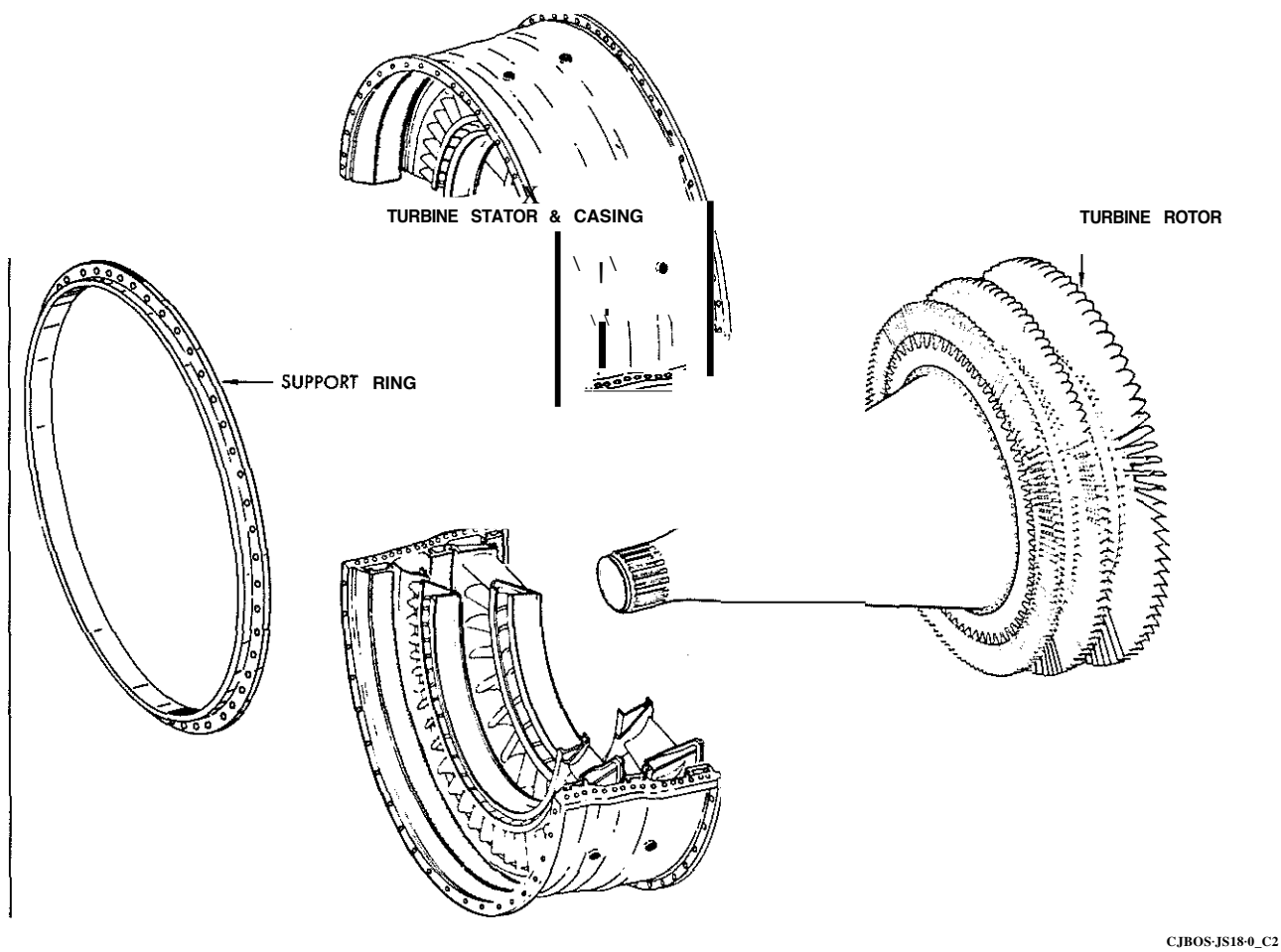
Inspect/Check	Maximum Serviceable Limit	Remarks
A. Cracks in:		
(1) Flange welds	**Not serviceable**	Replace engine.
(2) Boltholes	3 per flange that progress outward from bolt hole. None allowed that progress inward from bolt hole	Replace engine.
(3) Boss welds	One, 1/4 inch long per boss	Replace engine.
(4) Body	**Not serviceable**	Replace engine.
(5) Circumferential flanges other than bolt holes	**One radial crack per mating** flange provided it does not reach the flange to casing body radius	Replace engine.
(6) Horizontal flanges other than bolt holes	**One radial crack per mating** flange. Crack must not extend closer than 1/4 inch from the flange to casing body radius.	
B. Dents	Any number no deeper than 3/8 **inch and a min. diameter of 6** times the depth	
C. Bulge	**Not serviceable when associated** with heat discoloration	**Replace engine.**
D. Hot spots (discoloration)	Allowed if metal is not granular **and cracks are not present**	Replace engine.

NOTE: Hot spots which result in bulges indicates a probable damaged combustion liner in that area. **Remove engine and investigate liners.**

TURBINE SECTION - DESCRIPTION AND OPERATION

1. General. (See figure 1.) The turbine sectl0n consists of turbine support ring, turbine stator and turbine rotor assemblies. The turbine support ring is a fabricated steel spacer ring which is bolted between the rear flange of the outer combustion casing and the front flange of the turbine stator. It **acts as a spacer to provide interchangeability of the turbine stator casings.**

2. Turbine Stator Casings. The turbine stator forms the load-carrying skin between the outer combustion casing and the fan front frame and directs and **seals turbine interstage gases. It consists of a casing, 2 turbine nozzles** and 3 turbine shrouds, all of which are split in half along the horizontal centerline. The casing is a sheet metal weldment with a front and a rear flange, 2 locating slots for the turbine nozzles and 3 retaining slots for the shrouds. The second- and third-stage turbine nozzles are similar in construction to the first-stage nozzle and are slipped into the locating



Turbine Section
Figure 1

slots and held by pin bolts. The shrouds are panels, made of a honeycomb on a steel backing, that slip into the shroud retaining slots in the casing.

3. Turbine Rotor. The turbine rotor is a steel assembly consisting of a conical shaft, 3 wheels, 2 torque rings, baffles, seals and 3 stages of blades. The shaft, wheels, torque rings, baffles and rear air seal are bolted together. The turbine blades fit in wheel serrations and are retained in the wheels by locking strips. Inter-stage air seals, which are of steel honeycomb material, ride on the torque rings and are held stationary by the turbine nozzles. The rear of the assembly is supported by the stub shaft on the third-stage wheel and the No. 3 bearing in the fan front frame. The front of the assembly is supported by the spline on the front end of the conical shaft and the compressor rotor rear stub shaft. The turbine rotor is coupled to the compressor rotor by means of a self-locking bolt. The **turbine rotor provides the driving force for the compressor rotor and the accessory drives.**

4. Operation. The gases from the combustion section are directed into the turbine blades and cause rotation of the assembly which is directly connected **to the compressor rotor. The compressor rotor transmits the power to the accessory drive. In order to cool the internal areas of the turbine rotor,** seventh-stage air from the compressor rotor flows through the inside of the turbine shaft, between the wheels and out the rear stub shaft.

Gas streams leaving the first stage of the turbine are redirected by the second-stage nozzle. The cooling air that flows through the second-stage **vanes, besides cooling the vanes, is discharged and used to cool the rear** face of the first-stage turbine blades. Flow from the second-stage turbine wheel is redirected by the third-stage nozzle so as to impinge properly on the third-stage turbine blades. A turbine shroud is mounted over the tip of each stage of turbine blades. They serve as seals, ensuring that all the gases strike the blades instead of flowing over the tips.

TURBINE STATOR CASING - MAINTENANCE PRACTICES

1. General. The maintenance of the casing involves the external areas of the engine.

2. Inspection/Checks,

NOTE: Confirm suspected cracks, using spot fluorescent-penetrant per 89-1-8.

Inspect/Check	Maximum Serviceable Limit	Remarks
A. All areas for 'cracks	Any number of 1/8 inch cracks or indications	
B. Horizontal flange to casing welds	One per flange, 1/2 inch long	
C. Circumferential butt welds between all cones, flanges and ring halves for cracks	Two per weld, 3/8 inch long in each casing half provided cracks are a minimum of 3 inches apart	
D. Boss and collar welds for:		
(1) Cracks in boss weld	One crack, 3/16 inch long	
(2) Cracks in collar weld	One crack, 5/8 inch long	
E. Horizontal flange to circumferential flange corner welds for:		
(1) Cracks	One per corner weld, 5/8 inch long	
F. Outside surface of casing parent metal for:		
(1) Cracks	One per ring, 1/2 inch long (crack must not extend into weld)	
(2) Nicks, scratches, etc.	Any amount not exceeding 0.020 inch deep after removal of high metal	

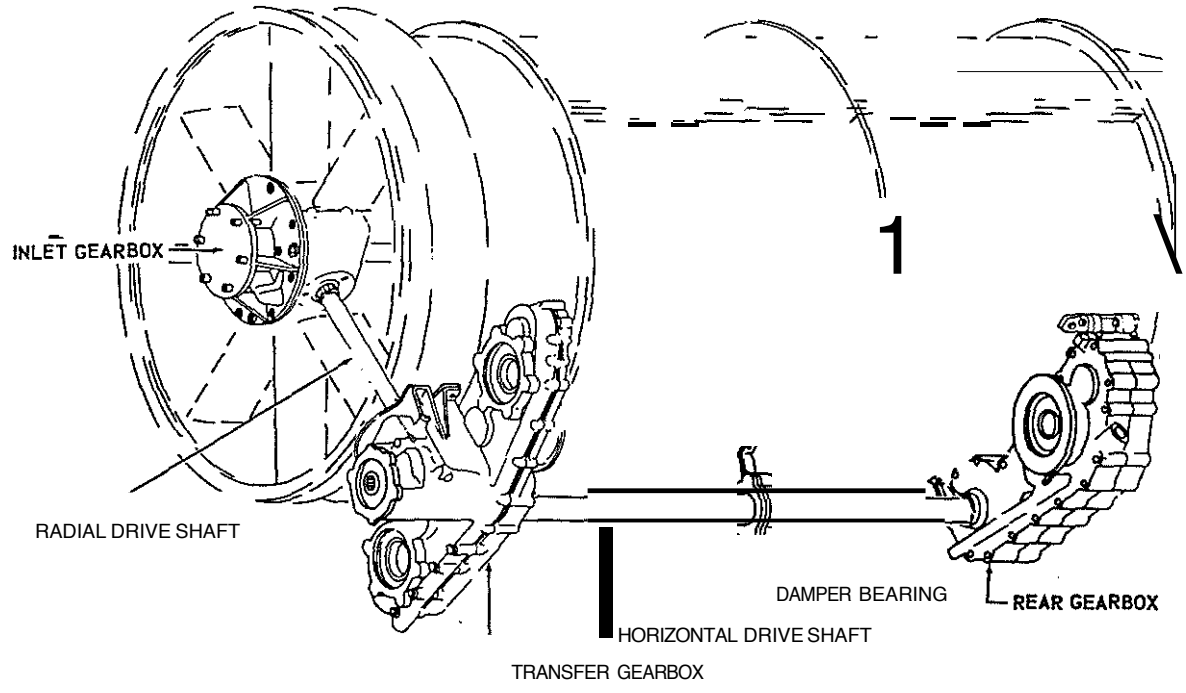
Inspect/Check	Maximum Serviceable Limit	Remarks
(3) Dents	Any amount not exceeding liB-inch deep	
G. Flanges for:		
(1) Bolt hole cracks	3 per flange, provided the cracks are outward	

H. Deleted.

3. Approved Repair. If the turbine casing serviceable limits are exceeded, the engine must be removed and the turbine casing-replaced with a matched set of casings.

ENGINE MAINTENANCE PRACTICES - APPROVED REPAIR

1. General. The repair that can he done with the engine installed is limited, except for some repair by replacement. Replacement of external tubes, hoses and accessories is covered in the maintenance discussion in each system. The repair of the basic engine that can be accomplished can he found in the appropriate section.

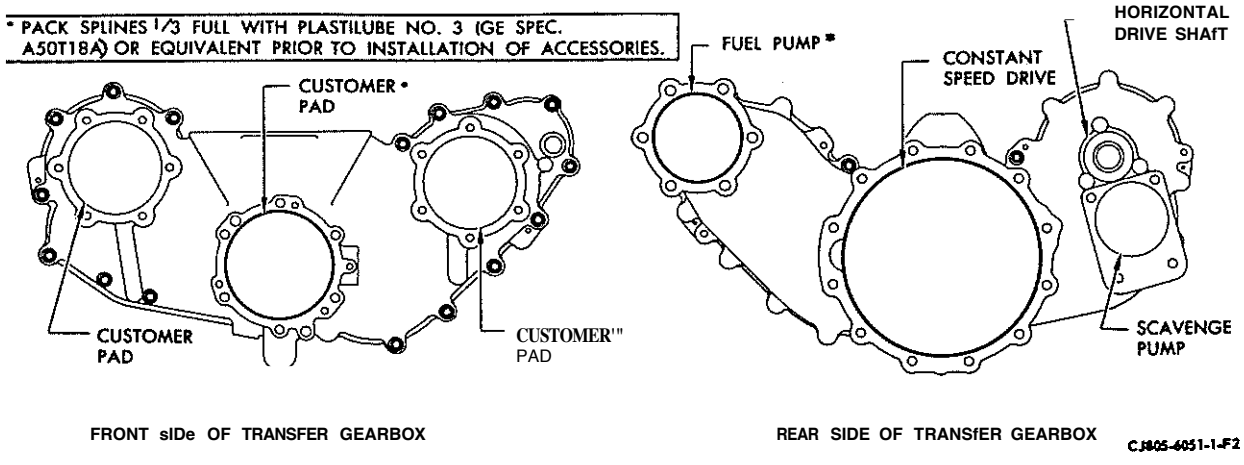


Accessory Drive Section
Figure 1

1. General. This section (figure 1) consists of an inlet gearbox, in the hub of the front frame; a transfer gearbox, on the bottom of the front frame; **and a rear gearbox, located on the lower compressor rear casing. The in-** let gearbox is connected to the compressor rotor at the front stub shaft and to the transfer_gearbox by a radial drive shaft through the bottom strut of the front frame. Power transmission from the transfer to the rear gearbox is accomplished through a 2-piece horizontal drive shaft coupled at a damper bearing. The accessories are mounted on the pads of the transfer and rear **gearboxes.**

2. Inlet Gearbox. The inlet gearbox is an assembly of a cast magnesium casing, a set of bevel gears and the associated bearings, oil jets and seals. The gearbox is bolted to the hub of the front frame and is splined into the front stub shaft of the compressor rotor. A mounting pad is furnished on the front of the casing. The inlet gearbox transmits the power from the compressor rotor to the radial drive shaft and in turn to the transfer gearbox. In addition, it makes a drive available for the front mounting pad and furnishes lubrication for the gears and the No. 1 engine bearing.

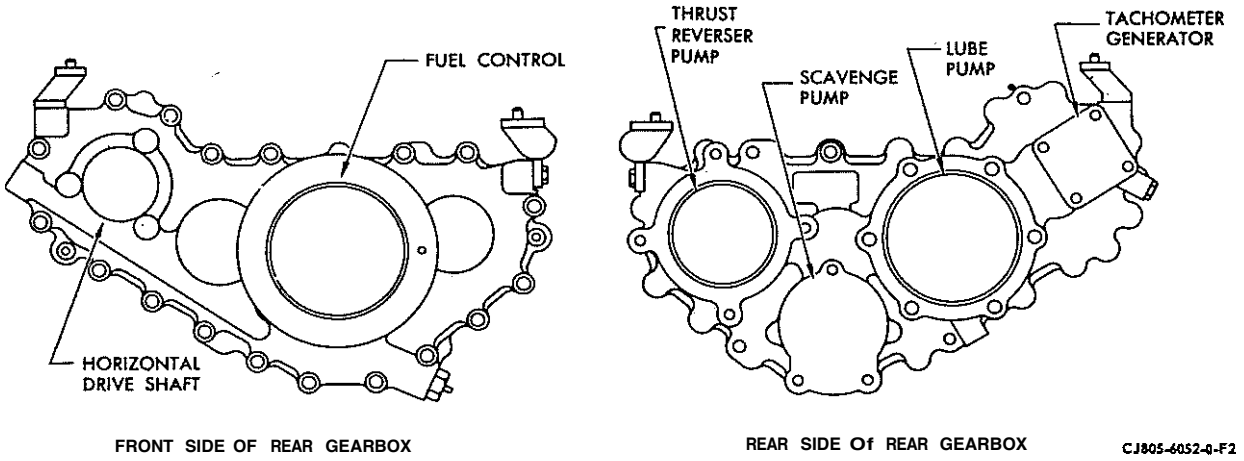
3. Transfer Gearbox. The transfer gearbox is an assembly consisting of a 2- **piece magnesium casting, a set of bevel gears, 8 spur gears and associated** bearings, seals and oil jets. The gearbox is attached to the bottom of the front frame by 5 bOlts. There are 6 mounting pads on which accessories are mounted, and a spline for the horizontal.drive-shaft which drive the rear gearbox. The usage of the pads is shown in figure 2.


* PACK SPLINES 1/3 FULL WITH PLASTILUBE NO. 3 (GE SPEC. A50T18A) OR EQUIVALENT PRIOR TO INSTALLATION OF ACCESSORIES.
CUSTOMER * PAD
CUSTOMER PAD
CUSTOMER'" PAD
FUEL PUMP *
CONSTANT SPEED DRIVE
HORIZONTAL DRIVE SHAFT
SCAVENGE PUMP
FRONT sIDe OF TRANSFER GEARBOX
REAR SIDE OF TRANSfER GEARBOX
CJ805-6051-1-F2

Transfer Gearbox Pad Usage
Figure 2

4. Horizontal Drive Shaft. The horizontal drive shaft is an assembly of 2 machined tubular-steel shafts, 2 tubular aluminum alloy housings and a damper bearing that joins the 2 shafts. The damper bearing bolts to the bottom of the rear compressor stator casing.

5. Rear Gearbox. The rear gearbox is an assembly consisting of a 2 piece **cast magnesium casing, 6 machined spur gears, and the associated bearings,** seals and oil jets. It is attached to pads on the lower rear compressor stator casing and is secured in place by 4 bolts. The usage of the drive pads is shown in figure 3.



Rear Gearbox Pad Usage
Figure 3

INLET GEARBOX - MAINTENANCE PRACTICES

1. General. The maintenance of the inlet gearbox will be minor. However, if **necessary, it can be removed and replaced.**

2. Removal/Installation. In order to remove the inlet gearbox it is necessary to remove the transfer gearbox and radial drive shaft first.

   A. Removal of inlet gearbox,

      (1) Remove the engine hub fairing from the inlet gearbox.

      (2) Remove the 8 bolts securing the inlet gearbox into the front frame.

         NOTE: If difficulty is experienced in removing the inlet gearbox, use puller, 2C4605.

   B. Installation of inlet gearbox.

      (1) Install a new a-ring on inner casing shoulder of the gearbox.

      (2) Install a new a-ring on the Oil IN port on the front frame hub.

      (3) Place the inlet gearbox in the front frame.

         NOTE: Make certain the v-rings remain in place.

      (4) Secure the inlet gearbox with bolts. Torque and lockwire.

      (5) Install the engine hub fairing on the inlet gearbox.

3. Inspection/Checks.

   A. Check for lube leakage from the flange of the inlet gearbox where it mates with the front frame. No leakage allowable.

   B. Check for lube leakage from between the cover plate and the gearbox casing. No leakage allowable.

   C. Check for nicks, dents or scratches on cast surfaces. Accept anything that can be removed by blending up to 3/32 inch deep and 1-1/2 inches long.

   D. Check for broken lockwire. No broken lockwire is permitted.

   E. Check entire body for cracks. No cracks are permitted.

4. Approved Repair.

   A. Leakage from between the inlet gearbox flange and the front frame can be corrected only by removing the gearbox.

B. **Leakage from between the covers and the gearbox casing can be corrected** by removing the cover and replacing the gasket.

TRANSFER GEARBOX - MAINTENANCE PRACTICES

1. General. **The maintenance of the gearbox is limited to the external section. If a problem concerning the interior of the gearbox arises the gearbox must** be replaced.

2. Removal/Installation. In order to remove the transfer gearbox, **it is first necessary to remove the horizontal drive shaft.**

A. Removal of transfer gearbox.

(1) Remove the accessories mounted on the gearbox. (Refer to maintenance **procedure for individual accessories.)**

(2) Remove gearbox mounting bolt that threads into the front frame through the constant speed drive mounting pad.

(3) Install lift fixture 2C4384 on the constant speed drive pad. Place a support under the lift fixture and bolt the fixture to the support.

(4) Remove the 4 nuts that secure the transfer gearbox to the front frame.

(5) Carefully lower the gearbox from the engine. As the gearbox is lowered, hold the radial drive shaft so it doesn't fall.

(6) Remove the radial drive shaft from the front frame.

B. Installation of transfer gearbox.

(1) Install a new O-ring on the mounting shoulder of the gearbox.

(2) Place the gearbox on fixture 2C4384.

(3) Place the radial drive shaft in the front frame, engage the splines and hold in place.

NOTE: The end of the shaft that fits into the inlet gearbox has "UP" marked on the end of the spline.

(4) With fixture 2C4384 secured to the adjustable support, raise the gearbox into position so that the mounting studs are through the holes in the gearbox and the radial drive shaft spline engages the spline in the transfer gearbox. Slight movement of compressor rotor by hand in either direction will align splines for engagement.

CAUTION: VERIFY SPLINE ENGAGEMENT BEFORE PROCEEDING WITH NEXT STEP BY OBSERVING MOVEMENT OF THE CONSTANT SPEED DRIVE SPLINE WHEN ROTATING THE COMPRESSOR ROTOR.

(5) Secure the gearbox to the front frame with the 4 nuts and washers. **Tighten in a cross-torque pattern.**

(6) Install a spacer between the gearbox and the front frame and secure with a bolt through the hole inside the constant speed drive pad. Torque and lockwire.

NOTE: Select the largest size spacer that will fit in between the front frame and the gearbox without forcing.

(7) Pack the main fuel pump, starter, and hydraulic pump splines 1/3 full with Plastilube No.3 (GE Spec. A50T18A) or equivalent prior to installation of accessories. **Install the accessories that mount on the gearbox. (Refer to maintenance procedure on individual accessories.)**

3. Inspection/Checks.

A. Check the casing for cracks especially in the web area around the front frame mounting pad. None allowable.

B. Check the cast surfaces for nicks. dents and scratches. Accept anything that can be removed by blending up to 3/32 inch deep and 1-1/2 inches long.

C. Check the casing for leakage. No leakage allowable.

D. Check secureness of nuts that retain gearbox.

E. Check Lok-thread studs for looseness and thread damage. Accept looseness that can be tightened by one turn. Accept thread damage if the total damage does not exceed the area equal to 3/4 of 1 full thread.

F. **Check sealing surfaces for scratches, nicks, and scores. Accept scratch**es 0.005 inch deep after removal of high metal. **Accept nicks and scores** 1/16 inch deep and not extending over 1/2 of the width after removal of high metal.

G. Check threaded holes for a-ring seat damage and thread damage. Accept damage to a-ring seat up to 0.005 inch. Accept thread damage if the total damage does not exceed the area equal to 3/4 of 1 full thread.

H. Check the splines for wear. Accept tooth wear not exceeding 35 percent of the tooth as measured across the top of the spline. Replace gearbox **if wear is uneven on contour of involute profile.**

I. Check for broken lockwire. Broken lockwire is not permitted.

4. Approved Repair.

A. Replace any gearbox that is cracked in casing.

B. Casings that are leaking should have the leak repaired provided the disassembly of the gearbox is not required.

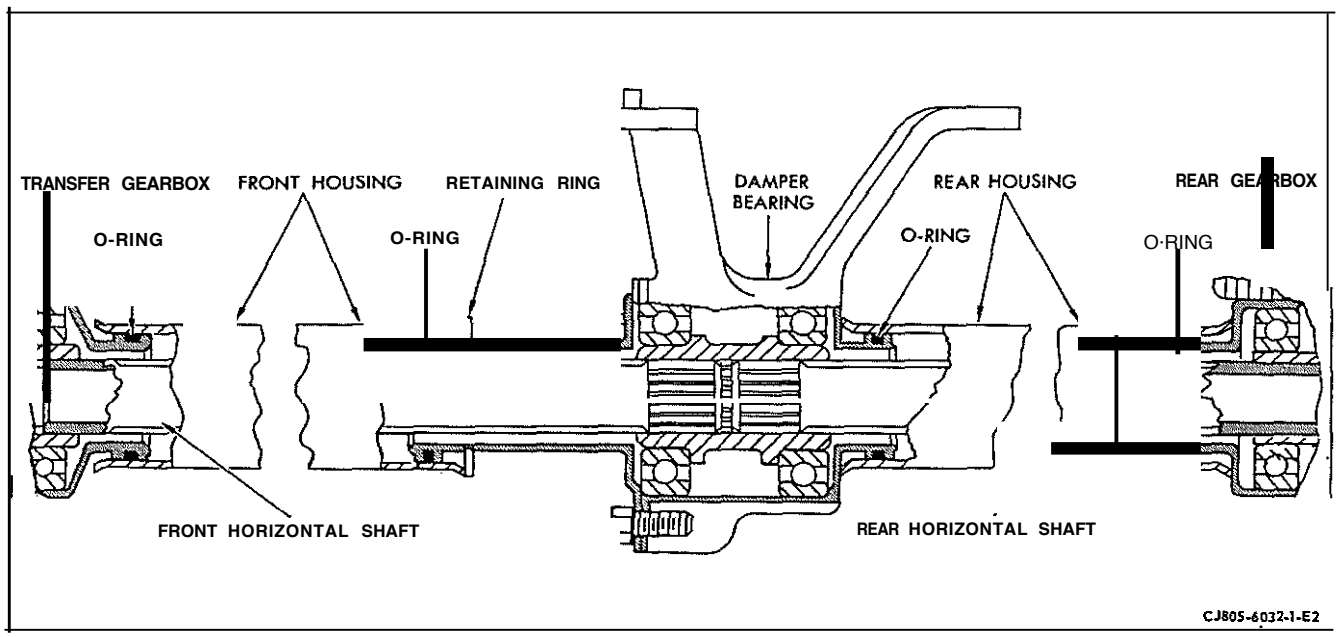
C. Replace Lok-thread studs, per 89-1-3, if beyond serviceable limits. **Chase serviceable threads if necessary_**

D. Replace broken lockwire, per 89-1-1.

E. Serviceable nicks, dents and scratches on the cast surfaces are to be blended, per 89-1-4.

DRIVE SHAFTS AND HOUSING - MAINTENANCE PRACTICES

1. General. The drive shaft itself is inaccessible without removing its housing. Although this can be accomplished, the maintenance will be primarily concerned with the external parts of the section.



Horizontal Drive Shaft Assembly
Figure 201.

2. Removal/Installation.

A. Removal of horizontal drive shaft. (See figure 201.)

(1) Disconnect and unclamp all lines from the damper bearings and shaft housing.

(2) Remove the bolts securing the damper bearing to the stator casing.

(3) Disengage the retaining ring that secures the front housing and allow it to hang on the damper bearing.

(4) Pull the damper bearing away from the stator casing and rotate it clockwise so that the mounting feet are away from the stator casing.

(5) Slide the damper bearing forward against the front housing.

NOTE: This will free the rear shaft and housing from the damper bearing. However, the rear shaft will still obstruct the removal of the damper bearing.

(6) Disengage the front shaft from the transfer gearbox by reaching inside the damper bearing with long-nose pliers and pUlling the shaft **to the rear.**

NOTE: This will free the front shaft and housing and the damper bearing. Do not let it fall.

(7) Remove the front shaft and housing and the damper bearing from the **engine as a unit.**

(8) Remove the rear shaft and housing from the rear gearbox.

B. Installation of horizontal drive shaft. (See figure 201.)

(1) Install new O-ring seals on the gearbox and the damper bearing.

(2) Install the rear shaft in the rear gearbox and slide the housing into position over the shaft.

(3) Install the front shaft in the transfer gearbox and slide the housing into position over the shaft.

(4) Install the damper bearing as follows:

(a) Position the rear shaft and housing against the engine and hold **in this position.**

(b) With the legs of the damper bearing facing away from the engine, slide the damper bearing over the front shaft and into the housing. Push the damper bearing as far forward as possible.

(c) Align the ends of the front and rear shafts so they are parallel with the centerline of the engine, and slide the damper bearing to the rear until it fUlly engages the rear housing.

NOTE: It may be necessary to align the splines of the shaft and damper bearing by turning the compressor rotor by hand.

(d) Rotate the damper bearing into. position and secure to casing with bolts. Torque and lockwire.

(5) Secure the front housing in position with the retaining ring on the damper bearing.

(6) Install and clamp all lines removed from damper bearing and shaft housings.

3. Inspections and Checks.

A. Shaft Housings

(1) Check for cracks. No cracks allowable.

(2) Check for nicks and scratches. Any number, any length are permitted provided they are no deeper than 0.015 inch and not on inside diameter where O-ring seats.

(3) Check for dents. Any number are permitted provided they are no deeper than 3/16 in.ch and not in area of a-ring seat.

(4) Check for leaks of a-rings at slip joints. No excessive leakage allowable.

B. Shaft Coupling and Bearing Housing Assembly.

(1) Check casing for cracks. No cracks allowable.

(2) Check casing for nicks and scratches. Any number allowable provided they are no deeper than 0.015-inch.

(3) Check for lube leakage. None allowable.

(4) Check a-ring seats for nicks and scratches. Accept minor damage after removal of high metal. Damage not acceptable if completely across sealing surface.

(5) Check for thread damage. Accept thread damage if total damage does not exceed the area equal to 3/4 of 1 full thread.

(6) Check for spline tooth wear. Tooth wear is not to exceed 35 percent of tooth as measured across top of spline. Replace housing assembly if wear is uneven on contour of involute profile.

C. Drive Shafts

NOTE: This inspection also applies to the radial drive shaft.

(1) Check for cracks. No cracks are permitted.

(2) Check for nicks, dents and scratches. Accept 1/32 inch on shaft and 0.015 inch on spline after removal of high metal.

(3) Check spline for tooth wear. Accept wear not exceeding 35 percent of tooth as measured across top of spline. Replace drive shaft if wear is uneven on contour of involute profile.

4. Approved Repairs.

A. Replace items that are out of limits.

B. Repair leakage where possible.

C. Repair damage to protective finish on casing with dichromate, per 89-1-4.

REAR GEARBOX - MAINTENANCE PRACTICES

1. General. The maintenance of the gearbox is limited to the external section. **However, the gearbox can be removed and replaced.**

2. Removal/Installation.

   A. Removal of rear gearbox.

      (1) Remove the accessories mounted on the gearbox. (See maintenance procedure for individual accessories.)

      (2) Disconnect lube and vent line from the gearbox.

      (3) Remove the bolts that secure the gearbox to the engine.

      CAUTION: HOLD THE GEARBOX IN PLACE SO IT DOES NOT FALL.

      (4) Slide the gearbox to the rear in order to disengage the horizontal drive shaft and housing. Remove the gearbox.

      NOTE: Remove the rear horizontal shaft and house so it is not dropped:

   B. Installation of rear gearbox.

      (1) Place a new O-ring on the horizontal drive shaft pad of the rear gearbox.

      (2) Align the rear horizontal shaft and housing so it is parallel with the center line of the engine. Hold in position.

      (3) Place the rear gearbox in position to the rear of the horizontal shaft. Slide the gearbox forward so the spline on the shaft fUlly engages the gearbox spline.

      (4) Secure the gearbox to the engine with bolts. Torque and lockwire. Lubricate the head of the two hinge bolts and the bracket slots with Plastilube No. 3 (GE Spec. A50T18A) or equivalent.

      (5) Pack the main fuel control and tachometer generator splines 1/3 full with Plastilube No. 3 (GE Spec. A50T18A) or equivalent prior to installation of accessories. Install the accessories that mount on the gearbox. (Refer to maintenance procedure for individual accessories.)

      (6) Connect lube and vent lines to gearbox.

3. Inspections and Checks.

   NOTE: Inspect the rear gearbox, using the inspection and repair section instructions on the transfer gearbox, chapter 72-4-2, paragraphs 3 and 4. Additional inspection is included below.

A. Check tachometer shaftgear spline for wear. Accept 0.005-inch wear **on a side. Replace tachometer shaftgear if limits are exceeded.**

NOTE: The tachometer generator must be removed for the above inspection.

4. Approved Repair.

A. Replace any gearbox that has cracks in casing.

B. Repair a casing that is leaking provided disassembly of the gearbox is **not required.**

NOTE: Leakage from the tachometer support can be repaired by using the procedure in paragraph C.

C. Replacement of damaged tachometer shaftgear or leaking seals.

NOTE: Complete disassembly of tachometer shaftgear assembly is given below but only the portion deemed necessary need be used.

(1) Remove the tachometer support from the rear gearbox by pulling it straight off over the studs. The tachometer shaftgear will come off with the support.

NOTE: At this point, the O-ring seal around the flange of the support **is exposed, and if leakage was the cause for disassembly, an** Lnspectn.on **and replacement of this a-ring seal may save** further disassembly.

(2) Disassemble tachometer shaftgear from tachometer support. (See figure 201.)

NOTE: Tool numbers referenced below are from tool set 2C4360.

(a) Remove the retaining ring from the slot in the tachometer support and let it hang loose on the shaftgear.

(b) Press the tachometer shaftgear assembly from the support, using pusher, -13P6, and plate, -12P2.

(c) Remove the carbon seal from the tachometer support, using pusher, -7P16. Remove O-ring seal from inside the tachometer support.

NOTE: The carbon seal need not be removed unless it or the O-ring seal is suspected of being unserviceable because of leakage.

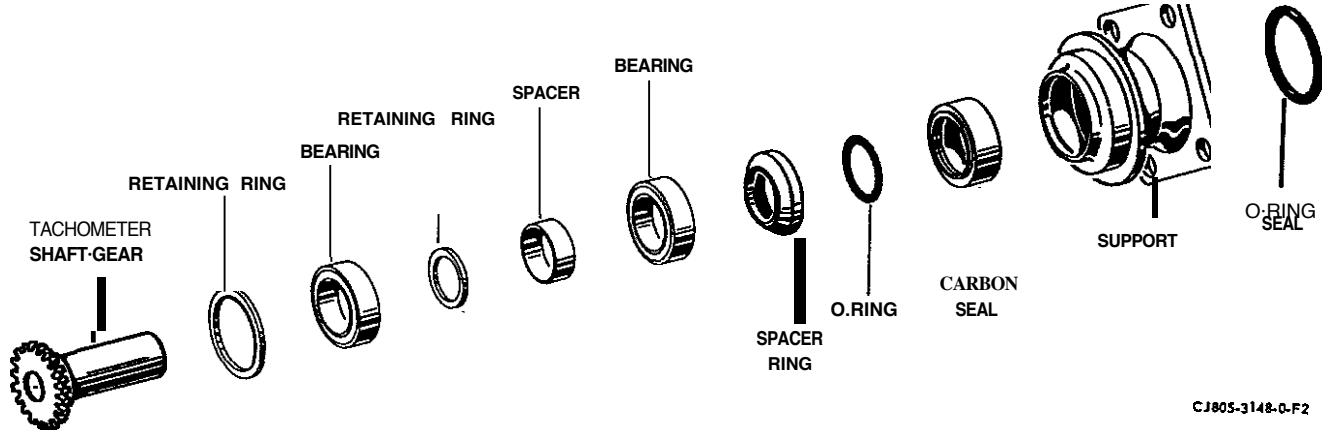
(d) Remove the spacer ring from the shaft.

(e) Remove the ball bearing from the **shaft, using press fixture,** -20; **ring,** -35, **and pusher,** -13P6.

(f) **Remove** the spacer from the shaft.

(g) **Remove** the **retaining ring.**

(h) Remove the ball bearing from the shaft, **using press fixture,** -20; support, -30Gl; **and pusher,** -13P6.



Assembly of Tachometer Shaftgear
Figure 201

(3) Assemble tachometer shaftgear in tachometer support. (See figure 201.)

NOTE: Tool number referenced below are from tool set 2C4360.

(a) Chill the shaft of the shaftgear.

(b) Grease a new O-ring seal. Install the seal in the groove in the inside diameter of the support. The groove is near the outer flange of the support.

(c) Press a carbon seal in the support. Use care when pressing the seal past the O-ring seal. Seat the seal, using pusher, -7P17.

(d) Loosely install the retaining ring of the support on the shaftgear.

(e) Install a ball bearing on the chilled shaftgear. Seat the **bearing, using pusher, -7P18.**

(f) Install a retaining snapring after the bearing.

(g) Place a spacer on the shaft, after the snapring.

(h) Install a ball bearing on the chilled shaft, and seat against the spacer, using pusher, -7P18.

(i) Install a new a-ring seal in the groove of the spacer ring. Apply a coating of grease to keep the seal in place.

(j) Install the spacer ring on the shaft. The chamfer side must be toward the bearing.

(k) Press the tachometer shaftgear assembly into the support until the bearing next to the gear just passes the snapring slot in the support.

(1) Insert the loose snapring on the shaft in the groove of the support to secure the assembly.

(4) Install tachometer support and tachometer shaftgear in rear gearbox.

(a) Install a new a-ring seal around the mounting flange of the support.

(b) Install the support in its mounting position with the cut out on the bottom of the support facing in the direction of the center of the gearbox.

(5) In testing, check for leakage during an engine run. No leakage is permitted.

LUBRICATION SYSTEM - DESCRIPTION AND OPERATION

1. General. The lubrication system (figure 1) is a recirculating system. The main lube and scavenge pump supplies high-pressure oil from the engine-mounted tank to the areas requiring positive lubrication, and 4 scavenge pumps return the oil to the tank. Filters remove foreign material from the oil, and coolers prevent the oil from rising to destructive temperatures. Air valves in the system maintain the correct pressure balance. The system performs the following functions:

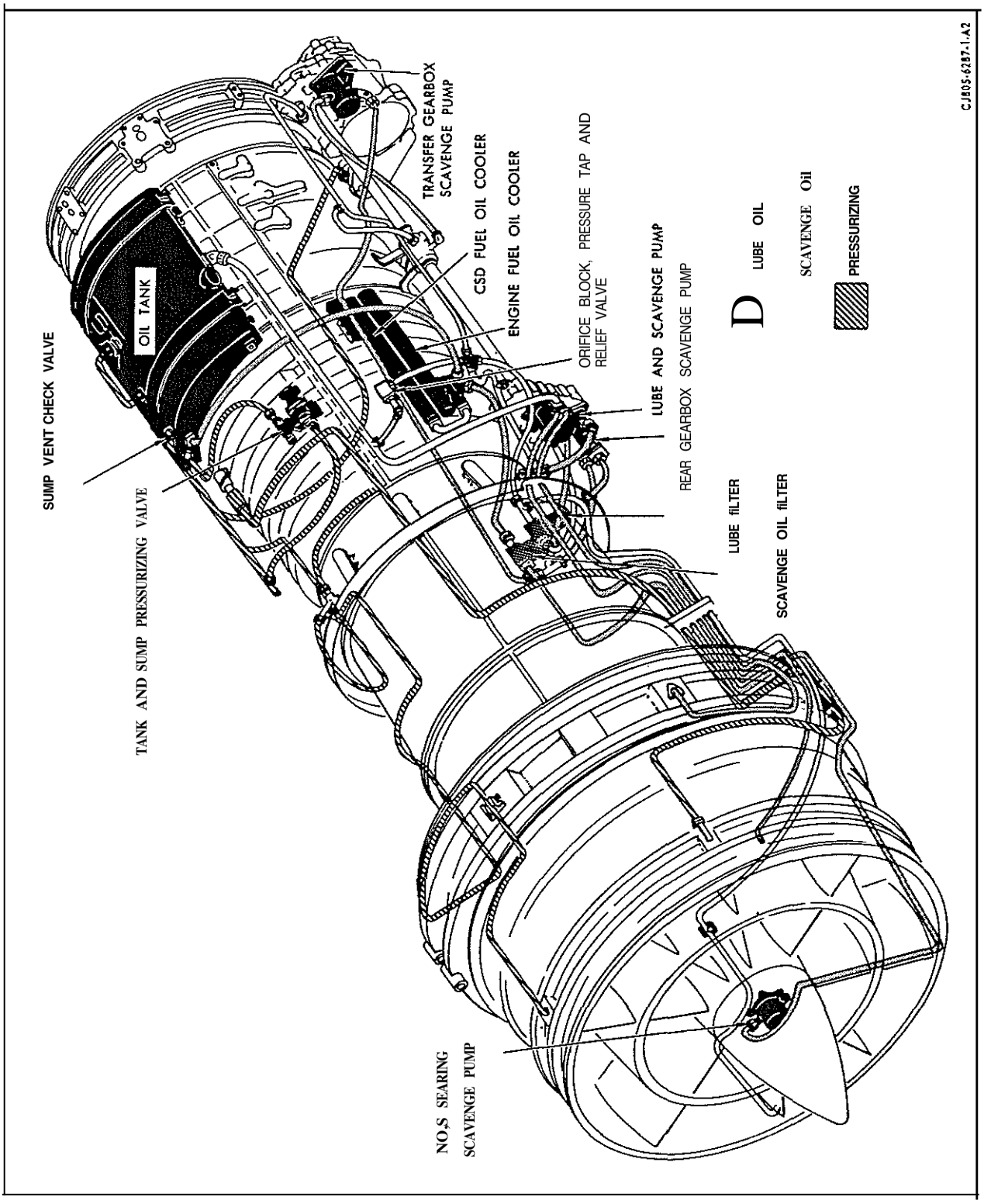
   A. Supplies oil to lubricate the 5 rotor support bearings and the gears and bearings in the gearboxes;

   B. Scavenges, filters and cools the used oil to prepare it for recirculation through the system.

   C. Regulates air pressure in the system to maintain a positive head of oil pressure at the inlet to the lube and scavenge pumps,and establishes a pressure differential across the bearing seals, thus controlling oil consumption.

   The components required to perform the above tasks are divided into 3 functional SUb-systems: the oil supply, the scavenge, and the sump and tank pressurization sub-systems. Figure 2 is a block diagram of the system. The purpose and location of each SUb-system component are as follows:

Component	Purpose	Location
Oil Supply Sub-System		
Oil Tank	storage of oil. A 2-compartment tank. Oil in one compartment is for the oil supply SUb-system. Oil in the other compartment is used for the hydraulic media in the thrust **reverser and constant speed** drive systems.	12 o'clock to 3 0'clock on the **compressor** stator casing
Lube and Scavenge Pump	One element receives oil at tank pressure and discharges oil at higher pressures to the lube oil filter. The 2 other elements scavenge oil from the No. 3 and 4 bearing sumps. This oil is discharges to the scavenge oil filter.	6 o'clock after face of rear gearbox
Oil Lube Filter	Filters the oil flowing from the lube pump to prevent the oil jet nozzles from clogging	**7:30 rear compressor casing**



Lubrication System (Engine layout)
Figure 1

1. SUMP VENT CHECK VALVE
2. TO OVERBOARD VENT
3. CSD AND THRUST REVERSER RETURN
4. **TANK PRESSURIZING VENT**
5. DE-AERATOR
6. TEMPERATURE REFERENCE TAP
7. DE-AERATORS
8. CSD AND THRUST REVERSER COMPARTMENT
9. SCAVENGE OIL FIITER
10. SUMP AND TANK PRESSURIZING VALVE
11. ANTI-G BAFFLES
12. FUEL OIL COOLER
13. ENGINE OIL DRAIN
14. THRUST REVERSER SUPPLY
15. OIL LEVEL
16. OiL SUPPLY
17. CSD SUPPLY
18. SCUPPER DRAIN
19. CSD AND THRUST REVERSER COMPARTMENT DRAIN
20. DOWNCOMER TUBE
21. SUMP PRESSURE REFERENCE TAP
22. FAN SPEED TACHOMETER
23. NO. 1 BEARING AND FRONT GEARBOX
24. PRESSURE RELIEF VALVE
25. OIL PRESSURE TAP
26. NO. 2 BEARING
27. NO. 3 BEARING
28. NO. 4 BEARING
29. NO.5 BEARING
30. BY/PASS FLOW
31. ORIFICE BLOCK
32. CHECK VALVE
33. SUPPLY OIL FILTER
34. REAR GEARBOX SCAVENGE PUMP
35. EDUCTOR
36. EDUCTOR
37. NO.5 BEARING SCAVENGE PUMP
38. TRANSFER GEARBOX
39. TRANSFER GEARBOX SCAVENGE PUMP
40. DAMPER BEARING
41. REAR GEARBOX
42. LUBE AND SCAVENGE PUMP

Lubrication System Schematic Diagram
Figure 2

Component	Purpose	Location
Oil Pressure Tap Lube Distribution Manifold	Contains 2 calibrated orifices which work with a pressure relief valve to protect the oil pressure transducer from extreme pressure surges.	8:30 compressor casing
Pressure Relief Valve	Limits the maximum pressure sensed by the transducer. By-passes extreme oil pressure surges from the lube pump discharge back to the lube pump inlet.	8:30 compressor casing
Oil Pressure Transducer	Supplied by airframe manufacturer. Senses oil pressure and generates an electrical signal for the cockpit indicator.	Connects to oil pressure tap
Oil Jet Nozzles	Spray lUbricating oil over the engine bearings, gears and seals.	In the gearboxes, and main bearing areas
Scavenge Sub-System		
Transfer Gearbox Scavenge Pump	Scavenges used oil from the -No. 1 bearing front gearbox, damper bearing and transfer gearbox. Discharges oil to the scavenge oil filter.	Right hand pad, after face of transfer gearbox
Rear Gearbox Scavenge Pump	Scavenges oil from the No. 2 bearing and rear gearbox. Discharges this oil to the scavenge oil filter.	6 o'clock after face of rear gearbox
No. 5 Bearing Scavenge Pump	Scavenges used oil from the No. 5 bearing and aft fan tachometer generator. Discharges this oil to the scavenge oil filter.	Inside the fan rear frame at the centerline of the after fan frame
Scavenge Oil Filter	Filters used oil received from the 4 scavenge pumps. Delivers oil to the engine fuel-oil cooler.	8 o'clock on rear compressor casing

Component	Purpose	Location
Engine fuel/oil Cooler	**Cools used oil received from** the scavenge oil filter by using engine fuel as the coolant. Oil discharged from the cooler returns to the oil tank.	3:30 o'clock com-**pressor casing**
Constant Speed Drive (CSD) Fuel/Oil Cooler	Supplied by the engine manu-**facturer to cool used return** oil from the CSD. Engine fuel is used as the coolant.	3:30 o'clock com-**pressor casing**
Air Oil Cooler	supplied by the airframe manufacturer to cool used oil returning from the constant speed drive (airframe accessory).	
Sump and Tank Pressurization Sub-Systems		
Sump and Tank Pressurizing Valve	Regulates pressure in the bear-**ing sumps, oil tank, gearboxes,** and connecting pipes.	**1:30 o'clock, com-pressor casing**
Sump vent Check Valve	Vents sump air pressure to tank yet prevents reverse oil flow.	In sump return connector on oil tank

2. Oil Supply Sub-System. Oil is stored in a 2-compartment oil tank. Oil from the engine section of the tank is gravity fed to the lube element of the main lube and scavenge pump which discharges the oil, through an anti-leak check valve, to the lube oil filter. Filtered oil flows to a tee and divides to supply the front gearbox, No. 1 bearing, transfer gearbox and the horizont"al drive shaft bearing forward of the filter. The other branch flows aft to **supply the rear gearbox, fan tachometer generator and main bearings No.2, 3,** 4, and 5.

   A. Oil is piped to the front gearbox and No. 1 bearing area through a passage in strut No. 5 of the compressor forward frame. Five jets distribute this oil. Eight jets distribute the oil in the transfer gearbox, and a small quantity is piped to lubricate the damper bearing.

   B. Three jets and a drilled orifice distribute oil in the rear gearbox.

   C. Oil for the No. 2 bearing is piped through strut No. 5 of the compressor rear frame; oil to No. 3 and 4 bearings is piped through strut No. 7 of the forward fan frame; oil for the No.5 bearing and tachometer generator is piped through strut No. 7 of the rear fan frame.

   D. The smaller forward section of the oil tank stores the oil used as the hydraulic medium in the thrust reverser and constant speed drive (CSD) systems. All oil lines and components, except the CSD fuel-oil cooler, **in these systems are furnished by the airframe manufacturer.**

3. Scavenge Sub-System. The scavenge sub-system scavenges the used oil from the sumps and gearboxes, cools and filters the oil and returns it to the oil tank.

   A. Scavenge oil from the No. 1 bearing sump and the inlet gearbox drains through strut No. 5 of the compressor front frame into the transfer gearbox where it is scavenged by the transfer gearbox scavenge pump. Used oil from the damper bearing is also scavenged by a second element of this pump. The discharge of the scavenge pump is routed to the scavenge oil filter.

   B. The rear gearbox scavenge pump consists of 3 independent elements. One element scavenges the oil from the gearbox itself. A second element scavenge No. 2 bearing climb sump flowing out of strut No. 5 of the compressor rear frame. Oil from the dive sump of No.2 bearing flows out strut No. 6 to a third element of the rear gearbox scavenge pump. The discharge of all 3 elements is routed to the scavenge oil filter.

   C. Two of the main lube and scavenge pump elements scavenge the No. 3 and 4 bearing sumps. The outlet of each sump drains through an eductor to ensure more positive scavenging. An eductor creates a suction on the sump outlet by directing a portion of the incoming bearing lube oil through an aspirator. The output of the 2 scavenge elements of the main lube and scavenge pump is piped through a common outlet to the scavenge oil filter.

   D. Lubricating oil drains through holes in the bottom of the fan speed alternator and accumulates in the No. 5 bearing sump. The No. 5 bearing scavenge pump, which is mounted on the fan tachometer generator, then pumps the oil from this sump to the scavenge oil filter through strut No. 5 of the rear fan frame.

4. Sump Pressurizing Sub-System. The sump pressurizing sub-system regUlates air pressure in the oil tank, gearboxes and bearing sumps. These areas are pressurized to ensure positive pressure at the inlet of the lube and scavenge pumps.

   The air used for pressurization is obtained primarily from air leakage across the bearing air-oil seals into the sumps. However, if insufficient air bleeds across the seals to prevent cavitation of the scavenge pumps, ambient air is permitted to enter the system.

   Air pressure in the sumps and gearboxes is equalized by connecting these areas with a manifold. The manifold is connected to the oil tank through a check valve. Thus, any excess of sump pressure will be vented to the oil tank. The valve will prevent any reverse flow of oil. The No.1 bearing and inlet gearbox are vented to the transfer gearbox through strut No. 5 of the compressor front frame. The rear gearboX also vents to the transfer gearbox but through the horizontal drive shaft. The transfer gearbox in turn vents to the pressurizing manifold. Bearings No.2 and 5 vent to the manifold through their respective struts, No. 1 compressor rear frame and No. 1 rear fan frame, while bearings No.3 and 4 vent through No.2 front fan frame strut.

All scavenge pumps are capable of pumping a greater quantity of oil than is present in the sumps. Therefore a large volume of sump air is pumped to supplement the oil. As the scavenge air-oil mixture passes through the de-aerator in the oil tank, the entrained air is separated from the oil. This air, plus any excess air that may enter the tank from the sump vent manifold, **pressurizes the oil tank. Some pressure is desirable, of course, but it must** be limited to 3 to 6 psi by the tank and sump pressurizing valve. The ability of the pumps to scavenge air creates a partial vacuum in the sumps at idle engine speed. Since the scavenge pumps may be damaged if operated under **extreme negative pressures, the sump and tank pressurizing valve opens at a** negative pressure between 1.5 and 2.5 psi and admits air at ambient pressure into the sumps.

5. Operating Characteristics. The lubrication system does not require control signals from the engine operator. Oil pressure and scavenge oil temperature indicators are located in the cockpit to monitor the system for proper operating characteristics. As long as pressure and temperature indicators are within limits and have not shifted suddenly, the system is operating properly. The following paragraphs explain the sequence of events that produce **normal indications.**

   A. Start: As the engine is air-motored, the lube pump produces a flow to the oil jet nozzles. The oil pressure indicator (measuring lube pump discharge pressure) begins to indicate some nominal value. If the oil is cold (ambient temperature around zero), the indicator needle may rise sharply and may peak as high as 200 psig. Orifices in the oil pressure tap, plus the protective action of the pressure relief valve, eliminate pressure surges above 200 psig. The 3 scavenge pumps are also activated by air-montoring, and return scavenged oil and air/oil mist to the oil tank. The 2 poppet valves in the sump and tank pressurizing valve remain closed until tank pressure increases enough to be vented to atmosphere or until the sumps are evacuated enough to require supplemental air from the atmosphere. Any slight scavenge oil temperature reading at this time is **insignificant, since the cool scavenge oil returning to the oil tank** is' bypassed around the core of the fuel/oil cooler.

   B. Engine Run-Up: Shortly after light-off and during the acceleration to **idle, both oil pressure and scavenge oil temperature rise as rpm increases. As rpm stabilizes, the oil pressure and temperature indicator** needles also stabilize. Generally this relationship between rpm and lubrication system readings applies during any acceleration or deceleration.

   Changes in engine speed also affect the amount of air flowing across the **bearing seals into the sumps. As a result, pressure surges occur in the** sumps but the fluctuations are minimized by components in the sump pres-**surizing SUb-system. Sump pressure regulation has been discussed previously**

   C. Shutdown. Oil pressure and scavenge oil temperature decrease with rpm **during the engine coastdown. The sump vent check valve, a one-way, flapper-type valve, prevents oil tank pressure from entering the sumps** at shutdown.

LUBRICATION SYSTEM - TROUBLE-SHOOTING

Trouble-Shooting information is furnished in Section 72-0.

5. Low Oil Pressure (During Engine Operation).

Probable Cause	Isolation Procedure	Correction
A. Defective indicating system	Refer to airframe indicating system trouble-shooting, Chapter 77.	
B. Defective lube pump		Remove and replace the pump (Refer to 72-5-2.)
C. External piping leaks	Inspect/check all visible piping.	Change defective piping.
D. Damaged oil jets or internal leaks		Replace gearboxes or engine.

6. Oil Temperature Rise.

Probable Cause	Isolation Procedure	Correction
A. Defective indicating system	**Refer to aircraft instructions.**	
B. Fuel-oil cooler defective	**Check oil temperature Ifinl! and noutl1 of cooler.**	**Replace cooler.**

7. High Oil Consumption.

Probable Cause	Isolation Procedure	Correction
A. External piping leaks	Inspect/check all visible piping.	Change defective piping.
B. Internal piping leaks	Check the lube-IN and lube-OUT struts of the turbine **frame and compressor rear frame.**	**Replace engine.**
C. Scavenge pump **defective**	Check for leakage from **bearing sumps**	Replace defective pump.
D. Oil foaming	**Check oil for contaminants.**	**Change engine oil.**
E. Sump pressure above normal	**Check sump manifold pressure** at idle speed. Should be -8 to -3 In. Hg. At 85 per-**cent, should be within -8 to zero In. Hg.**	**If pressure above normal trouble-shoot pressurizing system.** (See item 10.)

Probable Cause	Isolation Procedure	Correction
F. Faulty anti-static leak check valve allowing oil to drain into sumps and gear-box after en-gine shut-down	Remove check valve and check for sticking in open position (valve is located in the outlet port of the lube supply filter).	Replace valve.
G. Faulty No. 2 bearing carbon seal	Check for leakage from 17th-stage seal leakage struts (Nos. 3, 8 and 10).	Replace engine.

8. Change of 10 psi or More from Normal Operating Pressure.

Probable Cause	Isolation Procedure	Correction
A. Defective indi-cating system	See airframe indicating system trouble-shooting Chapter 77 or Aircraft Maintenance Manual.	
B. Clogged supply filter	Check filter screen	Clean filter. (Refer to 72-5-3.)

9. Increase in Oil Quantity (With No Increase in CSD Level).

Probable Cause	Isolation Procedure	Correction
A. Defective fuel-oil cooler	Take sample of oil and check for fuel.	Change oil cooler.

10. Sump Pressure Above Normal.

Probable Cause	Isolation Procedure	Correction
A. Leaking sump vent lines	Check fitting and lines for leaks.	Tighten or replace lines.
B. Sump pressuriz-ing valve de-fective	Check overboard vent for oil leakage -or- Remove valve and blow into vent port while holding the tank's pressurizing port closed. If passage is open valve is defective.	Replace valve.

Probable Cause	Isolation Procedure	Correction
C. Oil tank check valve defective	**Remove and inspect** check valve.	Replace valve.
D. Individual sump **or carbon seal** defective	Take individual sump readings.	Replace engine.

(1) Isolated No. 1 Bearing Sump and Gearbox Check.

(a) Disconnect the sump vent line that connects the No.2, 3, 4 and 5 bearing sumps to the sump vent manifold at the manifold. Cap-off manifold (leave lines open to atmosphere).

NOTE: The gearbox seal will leak if subjected to a high vacuum condition. Therefore the sump vent valve is left in the system by using the above method.

(b) Connect a manometer to the manifold.

(c) Operate the engine and read the manometer at IDLE and 85 percent power setting.

(d) The manometer reading should be less than a negative 4 inches of **Hg. for both power settings, if not, continue procedure to determine if problem is in front frame or gearboxes.**

(e) Block the overboard vent of the sump pressur1z1ng valve, a little at a time, until the manifold pressure gets up to PLUS 5 inches of Hg. Hold this pressure for five minutes.

(f) Check the gearbox casings and accessory seal drain for leakage. **If leakage is eVident, the problem is in the gearbox area, if no leakage, the problem is in the front frame sump area.**

(2) Isolated No. 2 Bearing Sump Check.

(a) Disconnect sump vent line that connects compressor rear frame to the manifold at the manifold. Cap-off the manifold.

(b) Connect a manometer to the No. 2 bearing sump vent line.

(c) Operate the engine at IDLE and 85 percent power settings.

(d) Check the manometer reading, it should be less than 0 inches of Hg. for both power settings.

(3) Isolated No. 3 and 4 Bearing Sump Check.

(a) Disconnect the sump vent lines from the tee connection at No. 2 strut of the fan front frame.

(b) Place a jumper line between the lines disconnected above.

(c) Connect a manometer to one side and cap-off the other side of the tee connector.

(d) Operate the engine and read the manometer at IDLE and 85 percent power settings.

(e) Check the manometer readings, it should be negative 7 inches of Hg. or less at IDLE and 0 inches of Hg. or less at 85 percent.

(4) Isolated No. 5 Bearing Sump Check.

(a) Disconnect the rear sump vent line from the tee connection at No. 2 strut of the fan front frame. Cap-off the tee connector.

(b) Connect a manometer to the No. 5 bearing sump vent line.

(c) Operate the engine and read manometer at IDLE and 85 percent power settings.

(d) The manometer reading should be plus 5 inches of Hg. or less at IDLE.

(e) At 85 percent the following limits apply. Engines with orifice in 9th-stage pressure line. (Number 3 strut on fan rear frame.)	Plus 15 or less
Engines without orifice.	Negative 15 or less.

LUBRICATION SYSTEM - MAINTENANCE PRACTICES

1. General. The information presented under system maintenance applies to the system as a whole. As such, this section deals primarily with system piping, clamping, etc. Maintenance information which applies to an individual component is presented as part of the maintenance information for that component.

WARNING: SYNTHETIC TURBINE LUBRICANTS WHICH ARE EXTENSIVELY USED IN AIRCRAFT TURBINE ENGINES, CONTAIN ADDITIVES WHICH ARE READILY ABSORBED THROUGH THE SKIN AND ARE CONSIDERED HIGHLY TOXIC. EXCESSIVE AND/OR PROLONGED EXPOSURE TO THESE LUBRICANTS TO THE SKIN SHOULD BE AVOIDED.

2. Servicing. The only servicing of the oil system that is required consists of checking the oil level in the engine compartment and the CSD compartment of the tank. Refer to General Electric, CJ805, Operations Engineering Bulletin No.7, for approved oils.

CAUTION: AVOID INTERMIXING TYPE 1 AND'TYPE 2 OILS OR DIFFERENT BRANDS OF TYPE 1 AND TYPE 2 OILS. IN THE EVENT OF NON-AVAILABILITY OR INADVERTENT MIXING OF OILS, THE ENGINE OIL SYSTEMS SHOULD BE DRAINED AT THE EARLIEST OPPORTUNITY; FLUSHED AND REFILLED WITH THE APPROVED OIL NORMALLY USED.

A. Check the oil level as follows:

(1) Engine compartment. Remove the cap and dipstick from the tank and check the level. Add oil only if dipstick indicates level is low by more than one quart. Make certain cap is locked when re-installed. **Airframe access panel cannot be closed unless cap is locked.**

(2) CSD compartment. Remove the cap and dipstick from the tank and check the level. Add oil if dipstick indicates a low level. Make **certain cap is locked when re-installed. Airframe access panel** cannot be closed unless cap is locked.

NOTE: Check the CSD compartment oil level immediately after the engine is shut down. The oil will drain, by gravity, from the tank to the system when the engine is,not running. The CSD system has a static shutdown capacity of approximately 0.4 gallons. After an engine is shutdown longer than several minutes, the tank appears to be low by approximately this a amount, although the system needs no oil.

B. Lubrication and scavenge system-draining and flushing. The following procedure is to be used when changing type and/or brand of lubricating oil.

(1) Drain lube, CSD and thrust reverser systems in the following manner and sequence:

(a) Oil tank. Loosen or remove filler caps from the main engine and CSD/thrust reverser oil tank. Open main engine and CSD/thrust reverser oil tank drain valves; drain and discard oil.

(b) Starter, CSD, transfer gearbox and rear gearbox. Remove drain/magnetic plugs from components; drain oil and discard.

(c) Damper bearing housing. Remove scavenge line at the damper bearing housing; drain and discard oil.

(d) Transfer gearbox and rear gearbox pumps. Thrust reverser pump (service taps only). Disconnect discharge lines at each pump discharge port. Drain and discard oil from discharge lines.

(e) Lube, scavenge and thrust reverser filters. Remove filter bowls; drain and discard oil from filter elements and filter bowls.

(f) Motor engine at 3% engine speed for 10 to 15 seconds.

(g) Allow oil to drain from all open ports and disconnected tubes and hoses for a minimum of 15 minutes. Discard oil.

(2) Flush lube and CSD systems in the following manner and sequence:

(a) Re-install all plugs, filter elements and filter bowls; reconnect all loose hoses and tubes. Tighten all connections, except CSD magnetic plug. Tighten to standard torque values. Close oil tank drain valves.

(b) Fill engine and CSD/thrust reverser oil tank, two-thirds full, with new oil.

(c) Fill starter (and if unmodified, also the CSD clutch compartment) with new oil.

(d) Motor engine and observe area of CSD magnetic plug. When a solid (no air bubbles) stream of oil is observed to be leaking from around the CSD magnetic plug; stop engine rotation and tighten CSD magnetic plug.

(e) Start engine and operate at idle speed for a minimum of 3 to 5 minutes. Actuate thrust reverser a minimum of 3 times.

CAUTION: OBSERVE APPLICABLE THRUST REVERSER OPERATING LIMITATIONS.

(3) Drain lube, CSD and thrust reverser systems as directed in paragraphs 2.B.(1)(a), through 2.B.(1)(e).

(4) Fill lube and CSD systems as directed in paragraph 2.B.(2)(a) through 2.B.(2)(e). Use neW O-rings and gaskets. Install clean filter elements. Replace oil identification cards. Fill to capacity with a **new oil.**

(5) Shut engine down and immediately check oil level in both the engine compartment and the CSD compartment. Fill to capacity if necessary.

C. Required precautionary checks for an engine with more than 250 hours TSO with oil being replaced with a different brand or type.

(1) After 25 hours of engine operation with the new oil, check lube, scavenge and thrust reverser filters for deposits, which would indicate contamination from prior oil used.

(2) Repeat check of filters after 50 and 75 hours.

(3) If filter deposits are greater than normal proceed as follows:

(a) Recheck must be made after next 25 hours.

(b) If contamination is excessive after 25 hour check, drain engine and refill with new oil.

(c) Repeat steps C.(1) and C.(2).

(4) If filters are normal at 75 hour inspection, resume normal filter **element inspection frequency.**

3. Removal/Installation. All external lines can be removed and/or installed by **employing normal maintenance procedures. When replacing lines, insert new O-rings and install new clamps where necessary. Lockwire all hose connector** nuts and all AN pad adapter bolts.

4. Inspection and Check. Inspect the following items during periodic inspections of the engine.

A. Studs, bolts, stand-off brackets, or braces to which accessories are fastened for secureness.

B. Lines and connections for leaks and/or evidence of wear.

C. Clamping of lines for secureness.

5. Approved Repair.

A. Tighten or replace fittings as necessary to stop leaks.

B. Tighten bolts, brackets and fasteners which secure accessories to the engine.

C. Tighten or replace clamping as necessary.

D. Remove and replace leaking and/or chafed lines. If asbestos covering (fire sleeve) is worn, remove the line from the engine, loosen the clamp on each end of the line and remove the covering. Check the line and if no damage is eVident, install new covering and tighten the clamps. Install the line on the engine,_ and lockwire.

E. Tighten hose and tube connections to correct torque values, and lockwire.

F. If leaks result from cross-threading or other damage to accessories, replace the accessory. Refer to maintenance instructions on the component to which the damage occurred.

Description - Power Plant, Fuel and Oil Systems

OIL SYSTEM

01. GENERAL (cont'd)

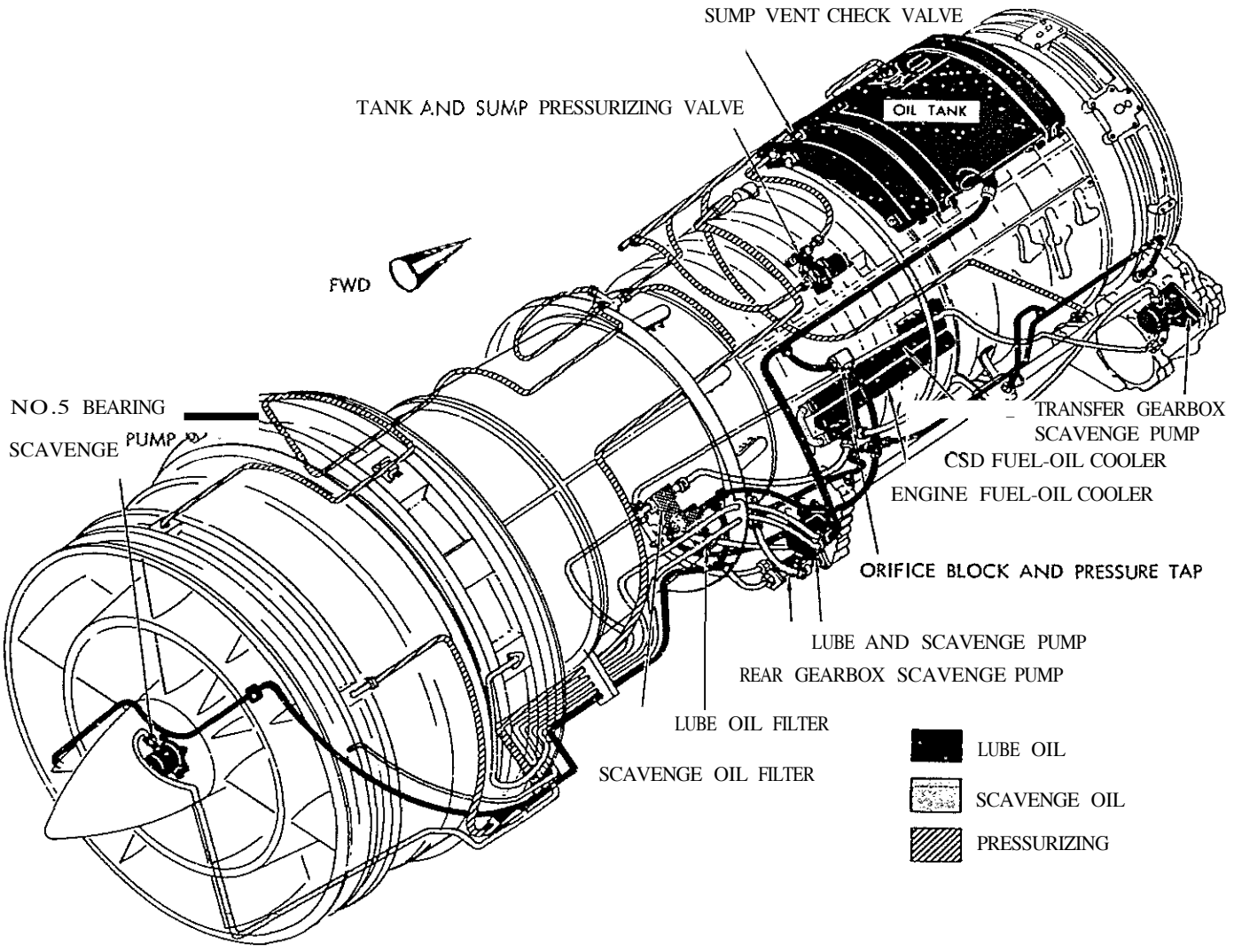


Fig 2 - Engine oil system (engine lay-out)

02. MAIN COMPONENTS AND SUB-SYSTEMS

(1) Oil supply sub-system

The oil tank is divided into 2 sections, namely the engine section and the constant speed drive section. Oil from the engine section is gravity fed to the lube element of the main lube and scavenge pump which discharges the oil, through an anti-leak check valve, to the lube oil filter. Filtered otl flows to a tee and divides to' supply the front gearbox, No. 1 bearing, the transfer gearbox and the horizontal drive shaft bearing forward of the filter. The other branch flows aft to supply the rear gearbox, fan tachometer-generator and main bearings No.2, 3, 4 and 5.

'The smaller section stores the oil used as the hydraulic medium in the thrust reverser and constant speed dr-Ive systems.

(2) Scavenge sub-system

Lube oil, as it is sprayed over the bearings and gears, absorbs heat and picks up metal. par-ticles or contamination from the gears. In order to use this oil again as a lubricant. it must first be cleaned and cooled. The scavenge sub-csystem performs these functions and returns the oil to the oil tank in condition for re-use in the oil supply sub-system.

The Iube system is of the "dr-y sump" design. That is, all sump areas ar-e constar..tly pumped dr-y of oil by the scavenge pumps. The capacity of the scavenge sub-system is appr-oxfmately 2.3 times as great as the amount of the lube oil distributed in anyone area. The balance is made up of sump pressurizing air. The advantages of this type of system in a jet engine are:

(a) Reduction in oil foaming.
(b) Reduction in gear drag.
(c) Reduction in temperature buildup within gearcases and bearing areas.
(d) Contributes to the design of a minimum volume lubrication system.

(3) Sump and tank pressurizing sub-system

The sump and tank pressurizing sub-system (see Fig 3) r-egulates the pressure of the air in the oil tank. the gearboxes and bearing sumps. These units are pressurized to assure a positive pressure at the inlet of the lube and scavenge pumps.

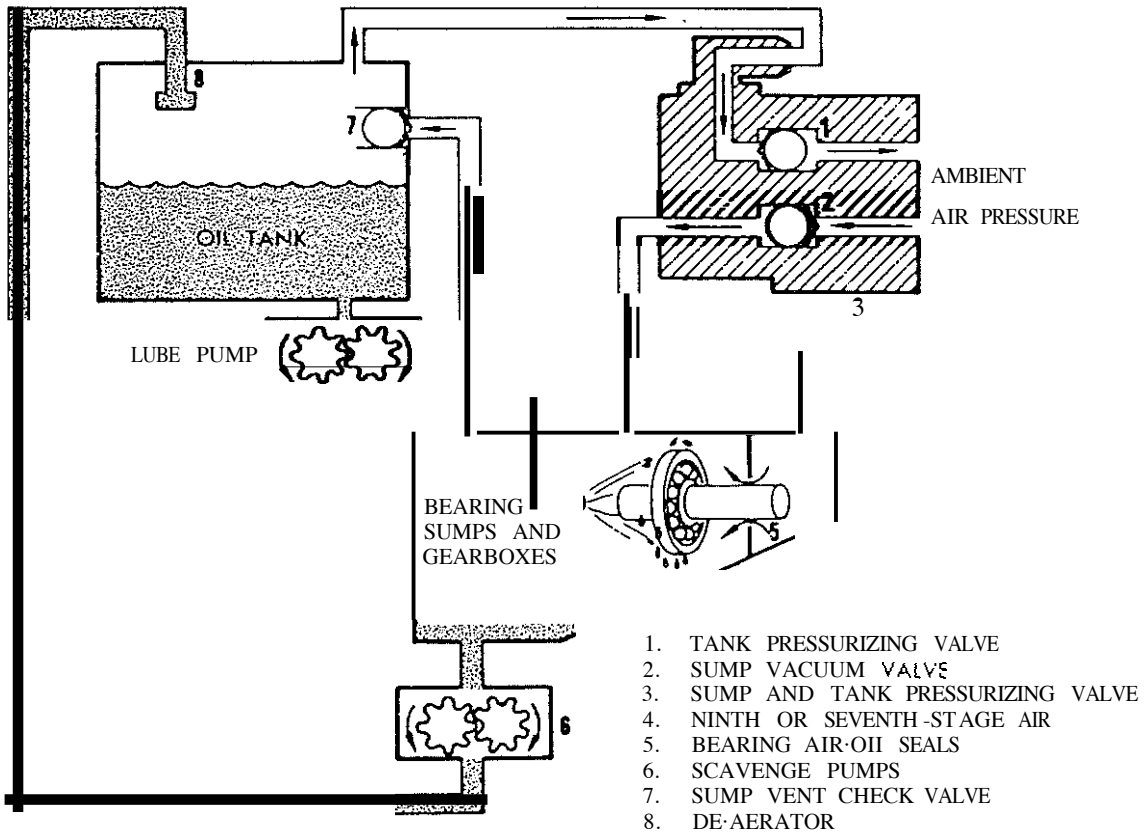
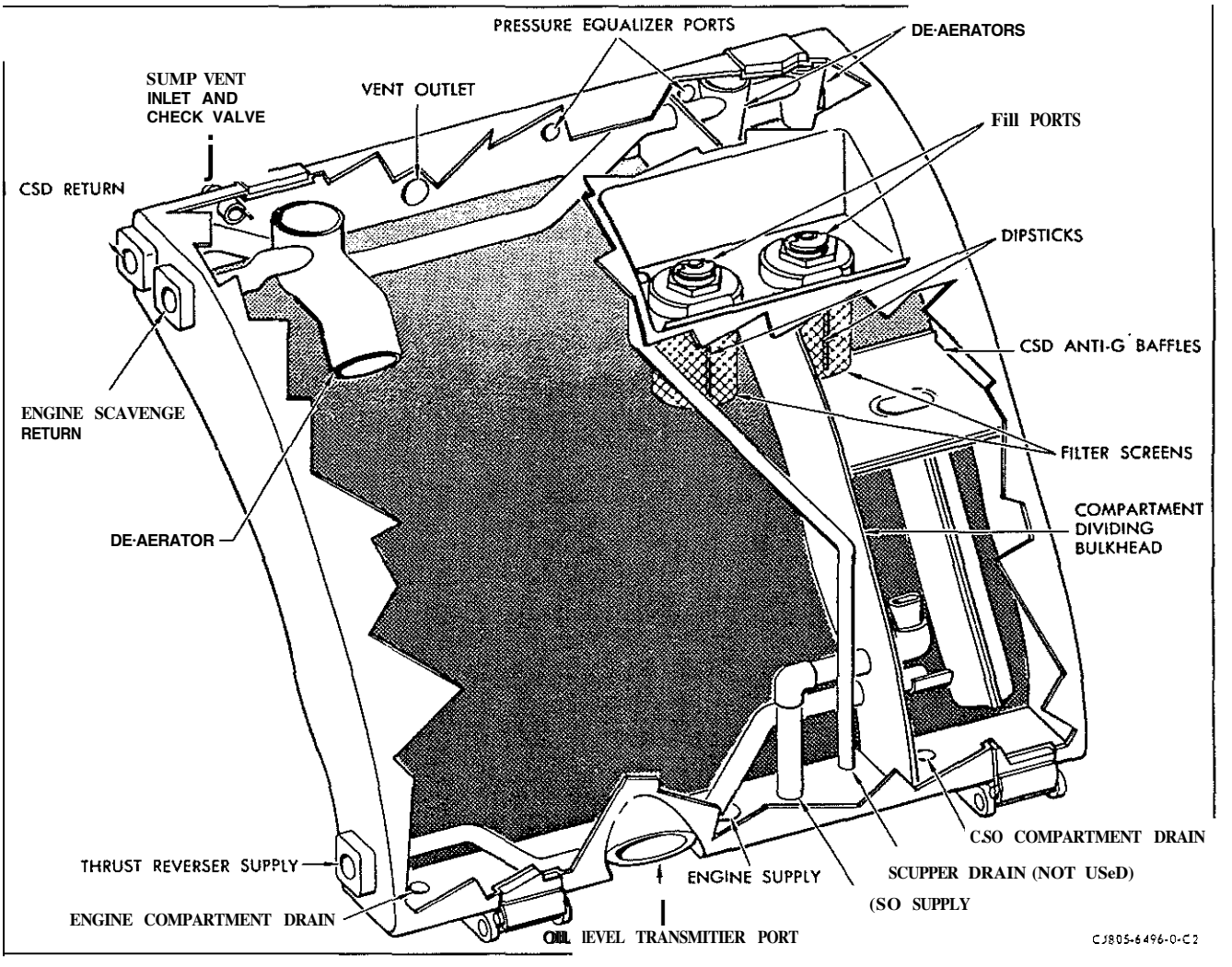


Fig 3 - Sump and tank pressurization sub-system

OIL TANK - DESCRIPTION AND OPERATION



Oil Tank
Figure 1

1. General.

A. The oil tank stores oil for the engine lubrication system, the constant speed drive (CSD), and thrust reverser hydraulic system. The tank is divided internally into 2 compartments. The engine compartment holds 4.1 gallons of oil, and the CSD and hydraulic compartment holds 1.7 gallons. The pressure in the compartments is equalized through a port at the top of each of the compartments which are interconnected by an external hose.

B. Each oil compartment has its own filler cap. The cap assemblies are equipped with filter screens, dipsticks and locking devices.

C. Each compartment has its own oil supply outlet, scavenge return port and drain port. The CSD compartment also contains a port for oil supply to the thrust reverser system.

D. A check valve installed in the sump vent port allows air flow into the tank. The check valve prevents the tank from compression due to ambient pressure rise during descent.

E. In addition to the solid bulkhead that divides the 2 compartments, the tank contains vertical and horizontal perforated bulkheads for strength and for protection against deformation from differential pressures. The tank contains the following ports:

(1) Main engine oil fill port

(2) CSD and thrust reverser oil fill port

(3) CSD and thrust reverser oil drain port

(4) Scupper drain port (not used)

(5) CSD supply port

(6) Main engine oil supply port

(7) Oil level transmitter port

(8) Main engine oil drain port

(9) Thrust reverser supply port

(10) Main engine oil return port

(11) CSD and thrust reverser oil return port

(12) Sump vent and inlet air relief port

(13) Overboard vent relief port

(14) Main engine oil air pressure equalizer port

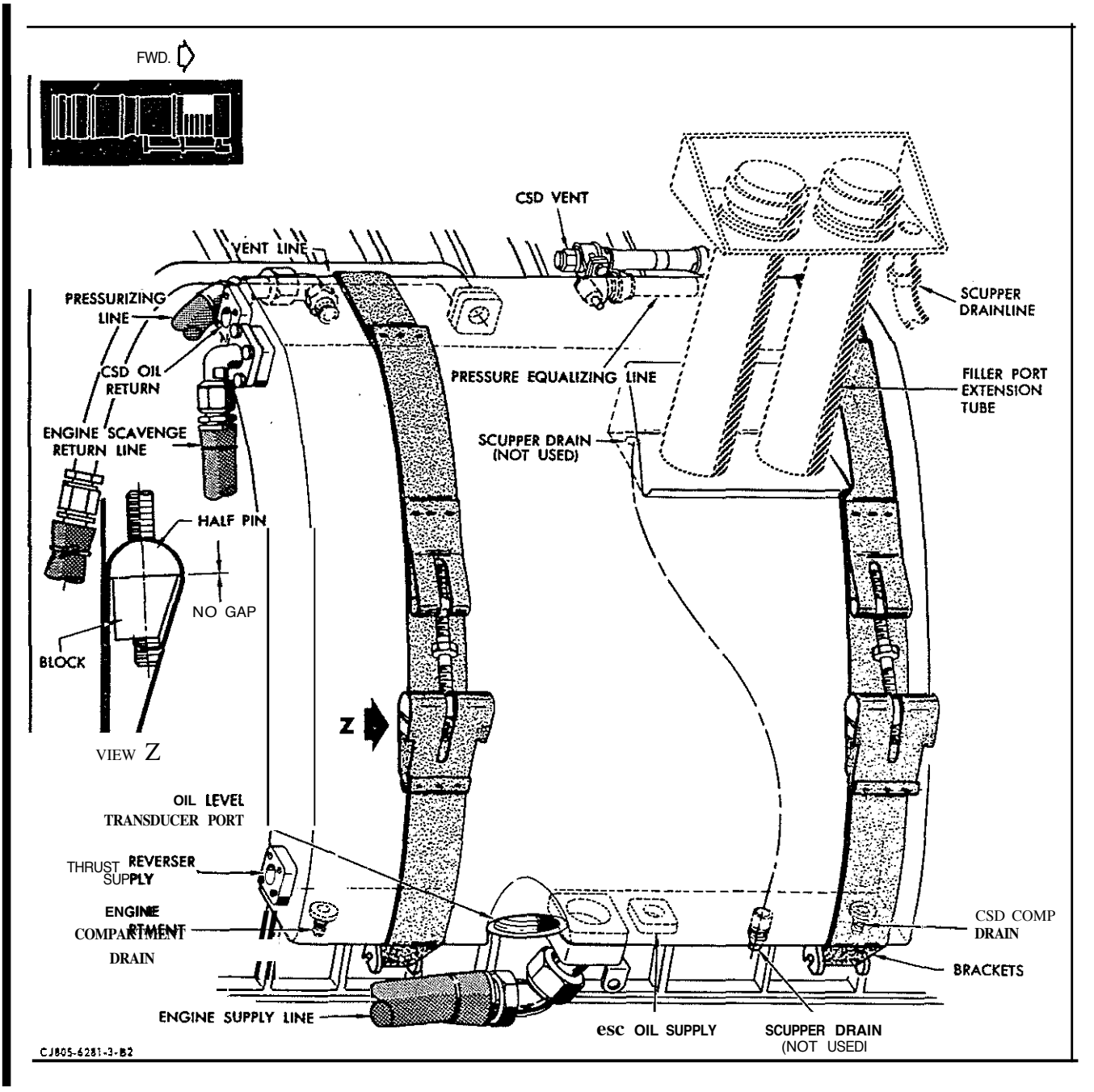
(15) CSD and thrust reverser oil air pressure equalizer port

F. De-aereators are located in the return lines to separate the air and oil as it returns to the oil tank. Chafing strips are cemented around the tank to prevent wear between the oil tank and the oil tank.mounting brackets.

G. Safety features of the tank include its steel construction, and baffling in the CSD compartment to ensure a continuous oil supply to the CSD and thrust reverser systems.

OIL TANK - MAINTENANCE PRACTICES

1. Servicing. The only servicing required on the oil tank is filling it when the level has dropped sUfficiently.



Removal/Installation of Oil Tank
Figure 201

2. Removal/Installation. (See figure 201.)

A. Removal.

(1) Drain both compartments of oil tank.

(2) Disconnect from the tank the lines listed below.

(a) Vent line (sump)
(b) Pressurizing line
(c) CSD oil return line
(d) Engine scavenge return line
(e) Thrust reverser supply line
(f) Engine oil supply line
(g) CSD supply line

(3) Remove oil tank filler port cap and extension tube, then disconnect **nacelle scupper drain line.**

(4) Remove electrical lead from oil level transducer.

NOTE: On retaining straps that have a turnbuckle in the strap, the turnbuckle should be loosened enough to free the lower end of the strap from the bottom bracket.

(5) Loosen strap adjustment nuts until strap retainer can be slipped out of bottom brackets.

(6) Remove ignition lead brackets from ,tank.

(7) Pull bottom of tank away from engine. Lift tank over ignition leads.

(8) Remove pressure equalizing line and fittings at top of tank.

(9) Remove oil level transducer from tank.

B. Installation.

(1) Assemble pressure equalizing line and oil level transducer to tank. Torque and lockwire fittings.

NOTE: Replace all a-rings. Inspect clad gaskets and replace if **evidence of cracks, scores, tears or distortion is found.**

(2) **Place tank on engine, approximately 7/8 inch from compressor stator** front flange. Rest tank on bottom mounting brackets.

(3) Check the oil tank position to see that it is supported by all four brackets by alternately pressing on the aft-upper corner and the **forward-lower corner of the tank.**

(a) If the tank does not rock proceed with installation.

(b) If the tank does rock, shim the forward-lower corner of the tank so there is no clearance between the tank using the following material:

Shim Material - Firewall sheet No. 95, Johns Manville or Rogers Corp., Duroid 3200 Buna or equivalent.

Bonding Agents - EC847 Minnesota Mining Epoxy
- GG59C Bondmaster. Rubber and Asbestos Corp.
- A576B B.F. Goodrich Company

(4) Position top mounting brackets against upper side of tank. Torque and lockwire the bolts that secure the brackets.

(5) Place the retaining straps over the tank and fit the lower end of the strap in the bottom brackets. Tighten as follows:

(a) On retaining straps tightened by nuts, the straps should be tightened uniformly by alternating tightening from one strap to the other. Tighten nuts to 55 lb.ins.

NOTE: Nuts that have nylon inserts are tightened to 110-120 lb. ins.

(b) On retaining straps with a turnbuckle the straps should be tightened by turning the turnbuckles until there is no clearance between the block and. half-pin on the bottom end. of the turnbuckle.

NOTE: When there is no clearance on the turnbuckle end, the strap is under the proper tension.

CAUTION: DO NOT TIGHTEN BEYOND POINT OF NO CLEARANCE.

(6) Check the clearance between the oil tank and the engine. Use a strip of 0.010 inch feeler stock and pass it under the tank.

(a) If the feeler stock passes freely, clearance is proper.

(b) If the feeler stock does not pass, the oil tank must be removed, shimmed, (refer to item (3) for materials) and reinstalled.

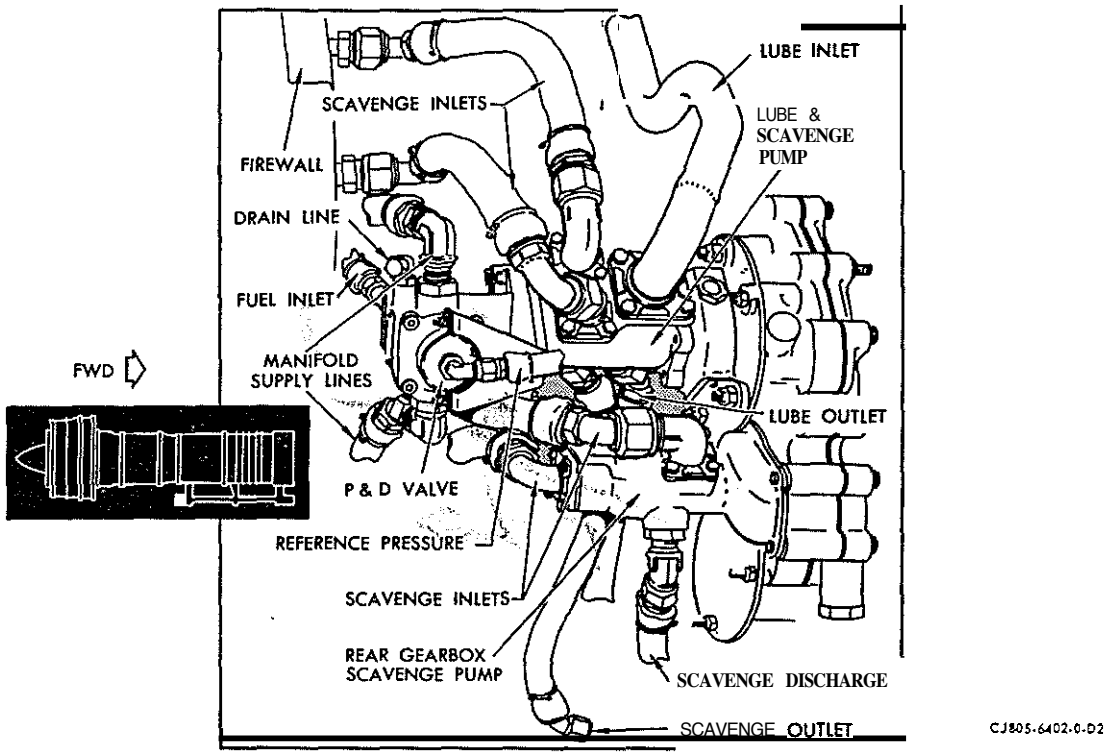
(7) Connect all piping listed under removal, step A.(2). Torque and lockwire all fittings.

(8) Connect electrical Wiring harness for oil level indicator.

(9) Fill both compartments of tank with clean lube oil. Lockwire all necessary connecLions.

(10) Turn engine over with ignition OFF to purge system of air, and check for leaks.

(11) Re-check level of oil in both compartments and fill to prescribed level.



Removal/Installation Lube and Scavenge Pump
Figure 201

1, Removal/Installation. (See figure 201.)

A. Removal

(1) Disconnect the drain line, the fuel inlet line, the 2 manifold supply lines and the reference pressure line from the pressurizing and drain valve at the valve.

(2) Disconnect the 2 scavenge inlet lines and the discharge line from the rear gearbox scavenge pump. Remove the scavenge pump from the **engine.**

NOTE: The rear gearbox scavenge pump is removed to gain access to the swivel nut at the lube outlet on top of the main lube and scavenge pump.

(3) Disconnect the lube outlet line on top of the lube and scavenge pump at the swivel nut close to the pump, Also on the top, the scavenge outlet line should be disconnected but at its opposite end where it contacts the tee tube of the scavenge oil filter.

(4) Disconnect the two scavenge inlet lines to the bottom of the lube and scavenge pump at their ends nearest the firewall of the engine.

(5) Disconnect the lube inlet line at the flange directly on the bottom of the lube and scavenge pump.

(6) Remove the six nuts and washers which secure the lube and scavenge pump to the rear gearbox and then remove the lube and scavenge pump-pressurizing and drain valve assembly from the engine.

(7) On bench, remove the 3 dangling hose assemblies and other hose fittings from the lube and scavenge pump. Also remove the 3 bolts and washers which secure the pressurizing and drain valve upper and lower brackets to the lube and scavenge pump.

B. Installation.

(1) On bench, install the pressurizing and drain valve and upper and lower brackets on the rear end of the lube and scavenge pump with 3 bolts and washers.

(2) Attach all hose fittings and the 3 hose assemblies to the lube and scavenge pumps, 2 scavenge inlets and one scavenge outlet. Use new gaskets and seals.

(3) Place the lube and scavenge pump-pressurizing and drain valve assembly on the engine. Secure the assembly to the gearbox pad and tighten nuts to standard torque value.

NOTE: Mate the splines of the pump and gearbox prior to mounting the assembly on the gearbox mounting pad studs.

(4) Connect the lube inlet line and flange directly on the bottom of the lube and scavenge pump.

(5) Connect the two dangling scavenge inlet lines to their respective hard lines near the firewall.

(6) Connect the lube outlet line to the top of the lube and scavenge pump. The .scavenge outlet line dangling from the top of the pump should be routed per figure 201 and connected to the TEE Tube at the scavenge filter inlet.

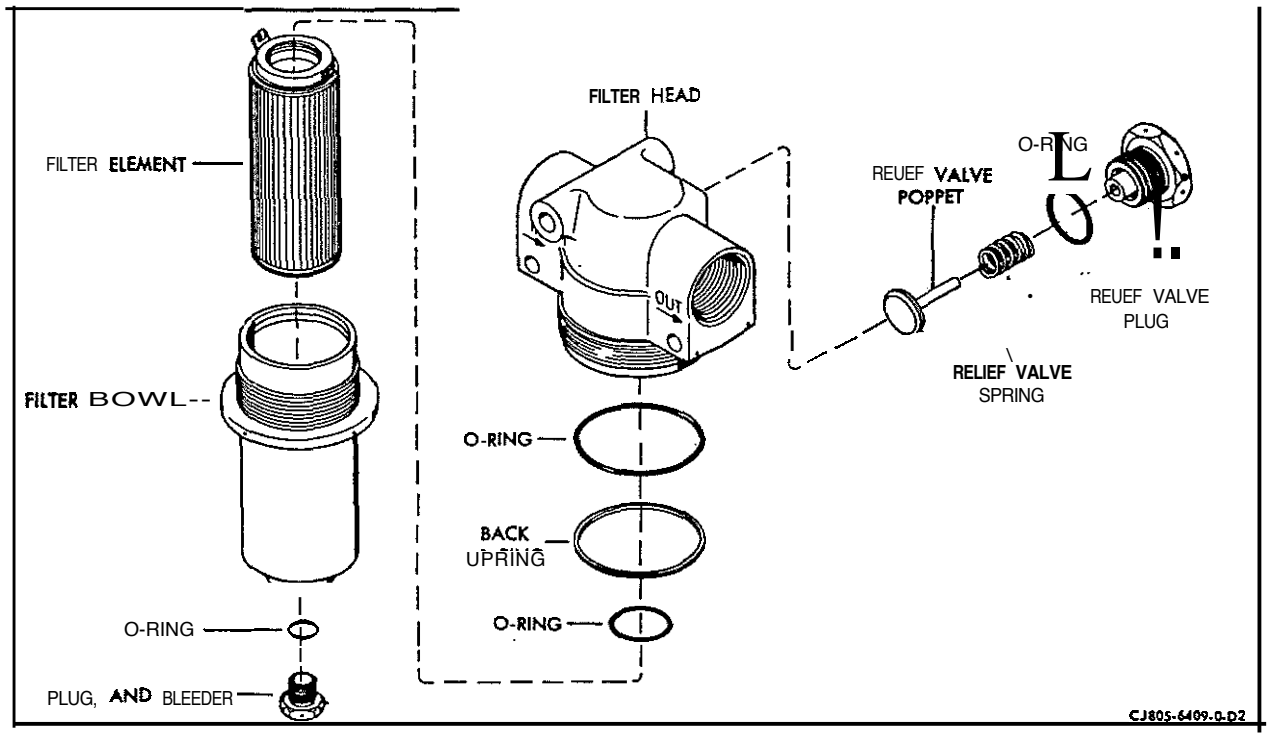
(7) Install the rear gearbox scavenge pump on the rear gearbox mounting pad and tighten nuts to the standard torque. Connect the 2 scavenge inlet lines and discharge line to the rear gearbox scavenge pump.

(8) Connect the reference pressure line, 2 manifold supply lines and the fuel inlet line to the pressurizing and drain valve.

(9). Tighten all bolts to standard torque and lockwire.

(10) Air motor the engine to purge the system and check for oil leaks.

LUBE AND SCAVENGE OIL FILTERS - MAINTENANCE PRACTICES



Exploded View of Oil Filters
Figure 201

1. Servicing. (See figure 201.) Clean the filters, using the following procedure.

   A. Remove the drain plug to drain the filter. Install the plug when filter is completely drained.

   B. Cut the lockwire on the filter bowl.

   C. Turn the filter bowl in a counterclockwise direction and remove it.

   D. Remove the filter element.

   E. Plug center of filter element with a cork or suitable stopper.

   F. Wash or soak the screen in carbon tetrachloride or trichlorethylene. Shake off excess fluid and blow dry with air.

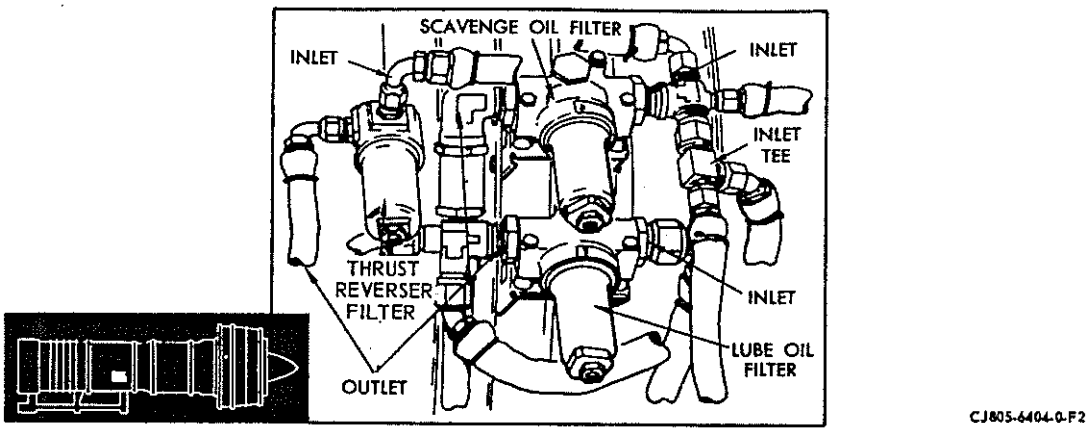
   G. Remove plug from filter element.

   H. Install the filter element.

   I. Install a new a-ring and fit the filter bowl to the head. Tighten the bowl hand-tight.

   J. Lockwire the drain plug.

   K. Lockwire the filter bowl to the heads.



Removal/Installation of Lube and Scavenge Oil Filters
Figure 202

2. Removal/Installation. (See figure 202.) Remove and install the filters as follows:

A. Removal

(1) Remove drain plug and drain the filter. Install the plug when draining is completed.

(2) Remove 3 holts and 2 spacers which secure filter to bracket. (If it is desired to remove the lube filter, 'the scavenge filter must be removed first.)

(3) Disconnect inlet and discharge lines and remove filter from the engine.

B. Installation.

(1) Place the filter on the engine and secure to the bracket with 3 bolts and 2 spacers. Tighten bolts to standard torque value.

(2) Connect the lines to the inlet and discharge ports of the filter. Tighten the connector nuts and filter drain plug to standard torque values, and lockwire.

3. Inspection/Check.

A. Check filter connections for leaks by air motoring the engine with the ignition OFF.

B. Make a continuity check of the magnetic chip detector.

4. Approved Repair.

A. Replace filter screen.

B. Servicing, per paragraph 1, page 201.

C. Replacement of filter assembly.

TRANSFER GEARBOX SCAVENGE PUMP - MAINTENANCE PRACTICES

1. Removal/Installation. (See figure 201.)

A. Removal.

(1) Disconnect the damper bearing scavenge inlet line and the scavenge discharge line from the pump.

(2) Remove the nuts which secure the pump to the gearbox mounting pad, and remove the pump from the engine.

NOTE: A gear is attached to the pump drive shaft. When replacing pumps, the gear must be removed from the old pump and installed on the new pump. Visually inspect the gear and if signs of wear, cracks, and/or chipped teeth are evident replace the gear.

B. Installation.

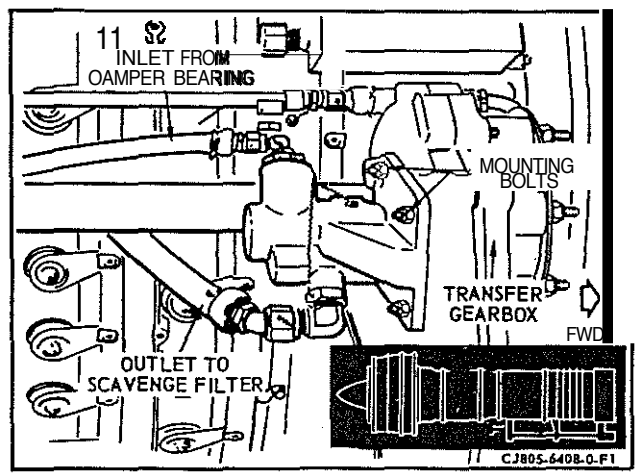
(1) Install new gasket on the gearbox mounting pad. Place the pump on the engine transfer gearbox. Turn the pump as necessary to mate the drive shaft with the gearbox spline, then rotate the pump until the studs can be inserted through the mounting holes. Secure the pump to the mounting pad studs.

(2) Connect the damper bearing scavenge inlet line and the scavenge discharge lines to the appropriate ports on the pump. Tighten the connector nuts to standard torque value, and lockwire.

(3) Tighten nuts to standard torque value, and lockwire.

(4) Motor the engine with the ignition OFF to check for leaks.

2. Inspection/Check. Visually inspect the pump for:



Removal/Installation of Transfer Gearbox
Scavenge Pump
Figure 201

A. **Loose line connections.**

B. Loose mounting bolts and nuts.

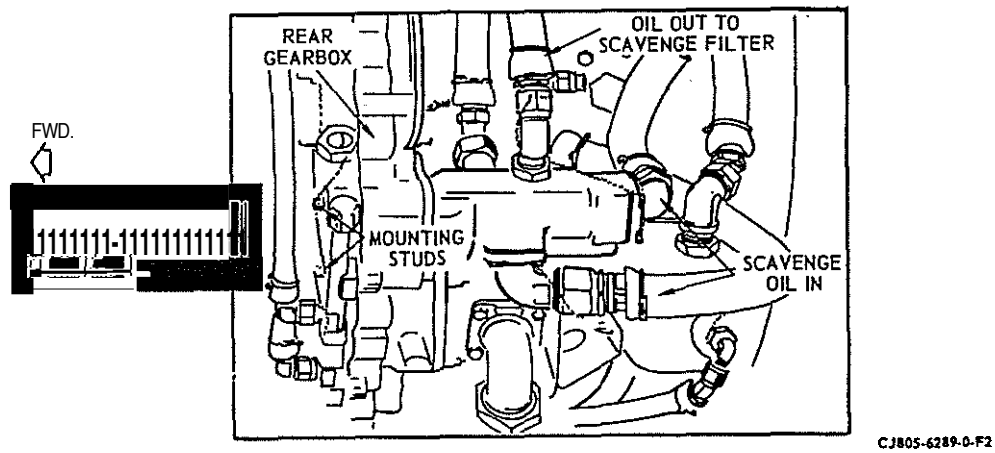
C. Leaks at connections.

3. Approved Repair.

A. Tighten all nuts, bolts, and fittings to standard torque values.

B. Remove and replace pump.

REAR GEARBOX SCAVENGE PUMP - MAINTENANCE PRACTICES



Removal/Installation of Rear Gearbox Scavenge Pump
Figure 201

1. Removal/Installation. .(See figure 201.)

A. Removal

(1) Disconnect the 2 scavenge inlet lines and the scavenge discharge line.

(2) Remove the nuts which secure the pump to the gearbox, and remove the pump from the engine.

NOTE: A gear is attached to the pump d.r-Lve shaft. When replacing pumps, the gear must be removed from the old pump and installed on the new one. Visually inspect the gear and if signs of wear, cracks, or chipped teeth are evident, replace the gear.

B. Installation.

(1) Install a new gasket on the gearbox pad. Place the pump on the engine. Rotate the pump as necessary to mate the pump drive hsaft with the gearbox spline, then rotate the pump to align the gearbox studs with the mounting holes. Secure the pump to the gearbox.

(2) Connect the 2 scavenge inlet lines and the scavenge discharge line.

(3) Tighten connectors bolts and nuts to standard torque values. Lock-**wire as necessary.**

(4) Motor the engine with the ignition OFF to check for leaks.

2. Inspection/Checks. Visually inspect the following:

A. Fittings and connections for leaks.

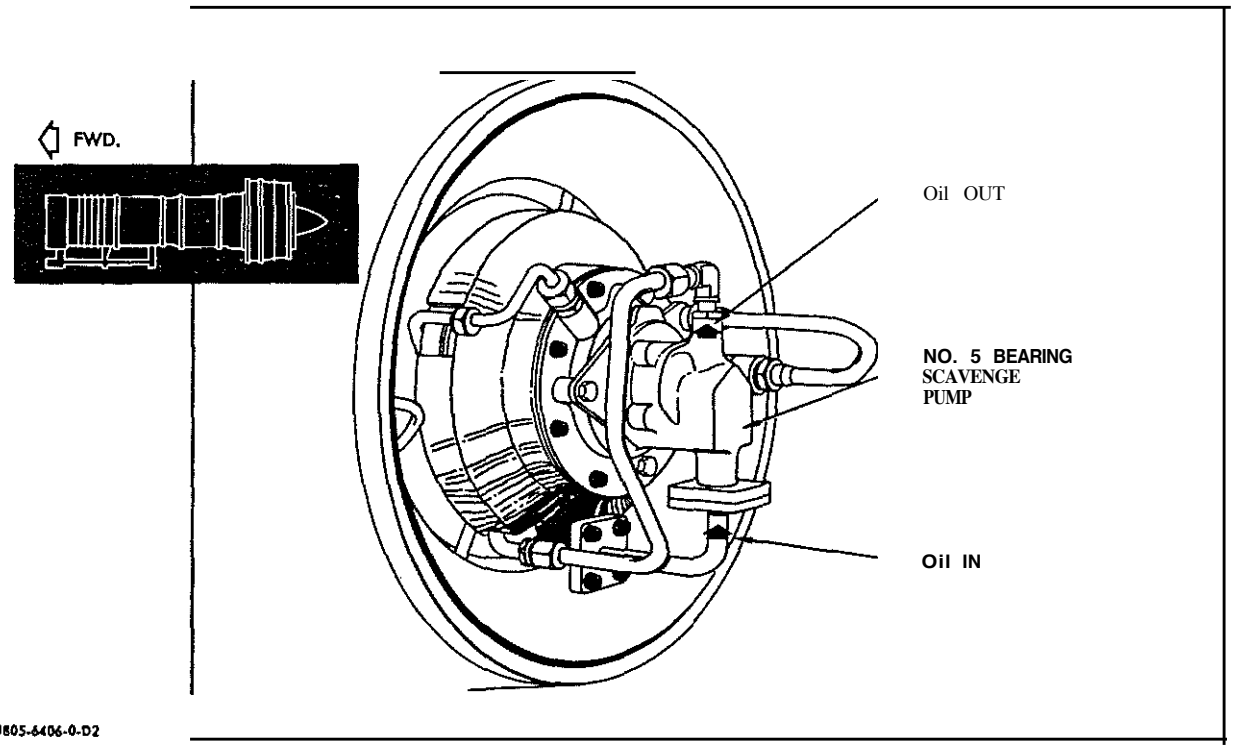
B. For loose mounting bolts, nuts and fittings.

3. Approved Repair.

A. Tighten all nuts, bolts and fittings to standard torque values.

B. Remove and replace pump.

NO. 5 BEARING SCAVENGE PUMP - MAINTENANCE PRACTICES



Removal/Installation of No. 5 Bearing Scavenge Pump
Figure 201

1. Removal/Installation. (See figure 201.)

A. Removal

(1) Remove 16 machine screws which hold the inner exhaust cone in place.

(2) Remove the inner exhaust cone.

(3) Remove insulation blankets from the pump, and the inlet and outlet lines.

(4) Remove the scavenge pump outlet and inlet tubes.

(5) Remove 4 machine screws which hold the scavenge pump to the rear surface of the fan tachometer generator; then remove the pump.

B. Installation.

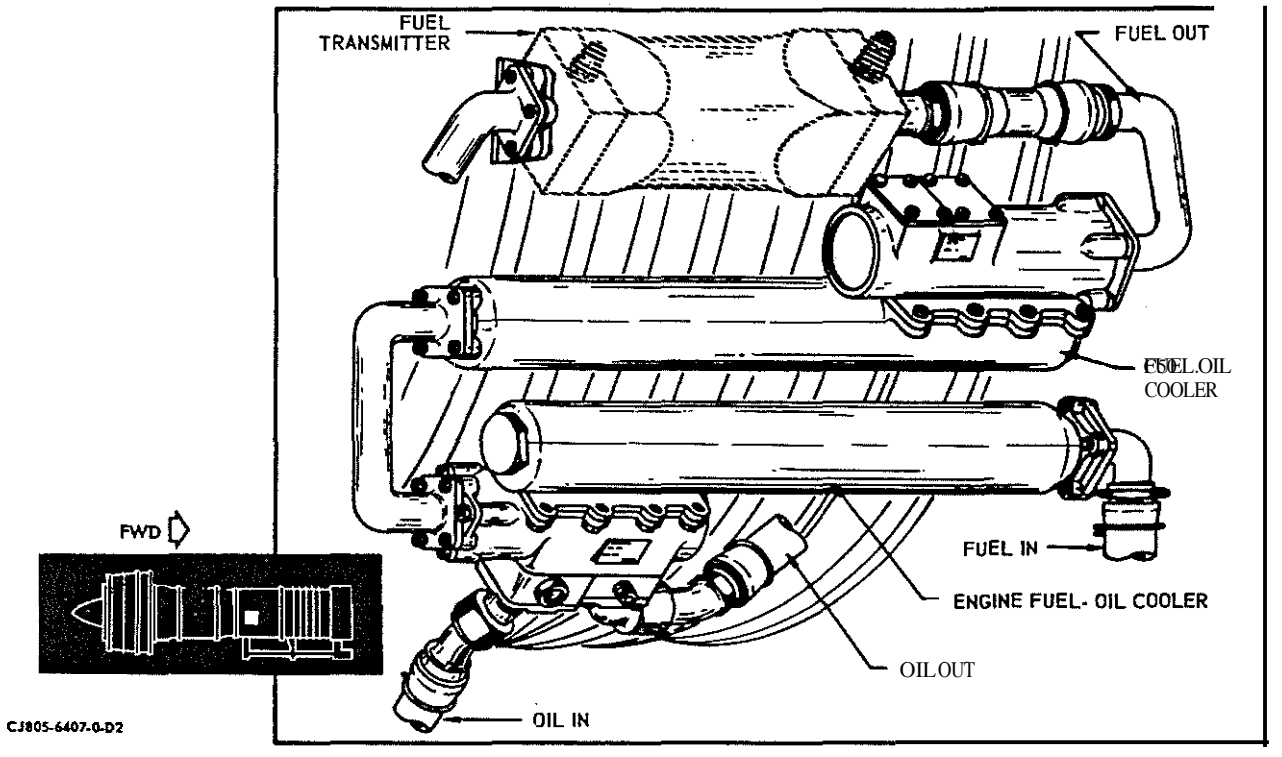
(1) Mount the No. 5 bearing scavenge pump, using a new gasket, on the rear face of the fan tachometer generator with 4 machine screws.

(2) Connect the inlet and outlet tubes to the pump.

(3) Install the insulating blankets around the inlet and outlet tubes and the lower and rear surfaces of the pump.

(4) Install the inner exhaust cone and fasten the cone and thermocouple harness in place with 16 machine screws.

ENGINE FUEL-OIL COOLER - MAINTENANCE PRACTICES



Removal/Installation of Fuel-Dil Cooler
Figure 201

1. Removal/Installation. (See figure 201.)

A. Removal

(1) Disconnect all **hoses from the cooler.**
(a) Fuel in
(b) Fuel out
(c) Oil in (For the CSD cooler, these **are airframe connections.)**
(d) Oil out

NOTE: Use container to catch any spilled fluid.

(2) Remove bolts holding cooler to mounting brackets.

(3) Remove the cooler.

B. Installation.

(1) Place cooler on mounting brackets and secure with mounting bolts. Tighten bolts to standard torque value, and lockwire.

(2) Connect all hoses **to cooler.**
   (a) Fuel in
   (b) Fuel out
   (c) Oil in (For CSD cooler, these are **airframe connections.)**
   (d) Oil out

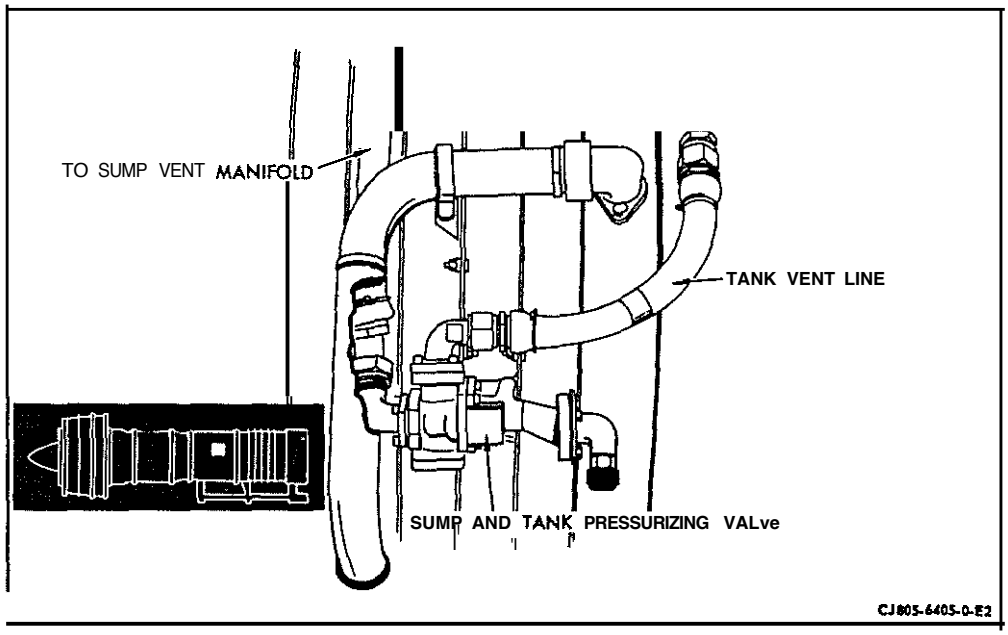
(3) Tighten all **hose connector nuts to standard torque values, and** lockwire.

(4) Perform prestart run and check for fluid leaks.

CONSTANT SPEED DRIVE (CSD) FUEL-QIL COOLER - MAINTENANCE PRACTICES

(Refer to maintenance practices for fuel oil cooler 72-5-7, Page 201.)

SUMP AND TANK PRESSURIZING VALVE - MAINTENANCE PRACTICES



Removal/Installation of Sump and Tank Pressurizing Valve
Figure 201

1. Removal/Installation.

   A. Removal

      (1) Disconnect tank and sump manifold hoses from the valve.

      (2) Remove bolts holding the valve assembly to the compressor mounting bracket.

   B. Installation

      (1) Place new valve in position and install the mounting bolts.

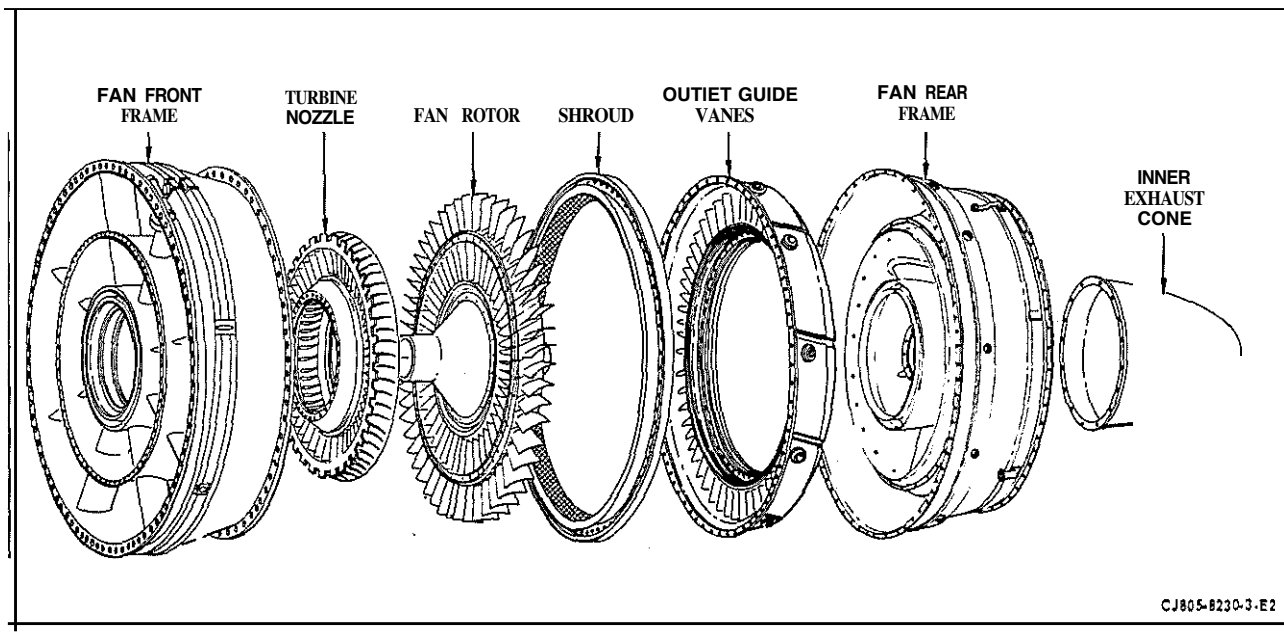
      (2) Install air lines from oil tank and sump manifold.

2. Inspection/Check. Check to see that all hose connector nuts and all mounting bolts are tight.

3. Approved Repair. Remove and replace.

FAN ASSEMBLY - DESCRIPTION AND OPERATION

1. General. The fan assembly consists of fan front frame, fan rotor shroud and fan rear frame assemblies. (See figure 1.)



Fan Section
Figure 1

2. Fan Front Frame. The fan front frame is a welded and riveted steel assembly consisting of an outer, an intermediate and an inner skin connected by 8 equally-spaced struts. It is constructed to form 2 concentric, annular-flow passages. The No. 3 and No. 4 bearing and seal supports are bolted to flanges in the inner hub of the frame. Fairings around the portions of the struts that are exposed to the primary gas-stream protect the struts against excessive heat. The inner flange of the fan trubine nozzle is bolted to the rear inner flange of the frame. The front axial air seal support is bolted over the outer flange of the turbine nozzle to the rear intermediate flange of the frame. The front intermediate flange of the frame is bolted to the rear flange of the turbine stator casing.

3. Fan Rotor Shroud. The fan rotor shroud is a circular, honeycomb strip welded to a mounting support. Both parts are made of stainless steel. The honeycomb sections are filled with epoxy resin. The complete assembly is bolted between the outer rear flange of the fan front frame and the outer front flange of the fan rear frame, over the tips of the fan rotor blades. With this type seal, extremely close blade tip-clearance Can be maintained, thus ensuring the flow of all secondary air through the compressor section of the fan blades.

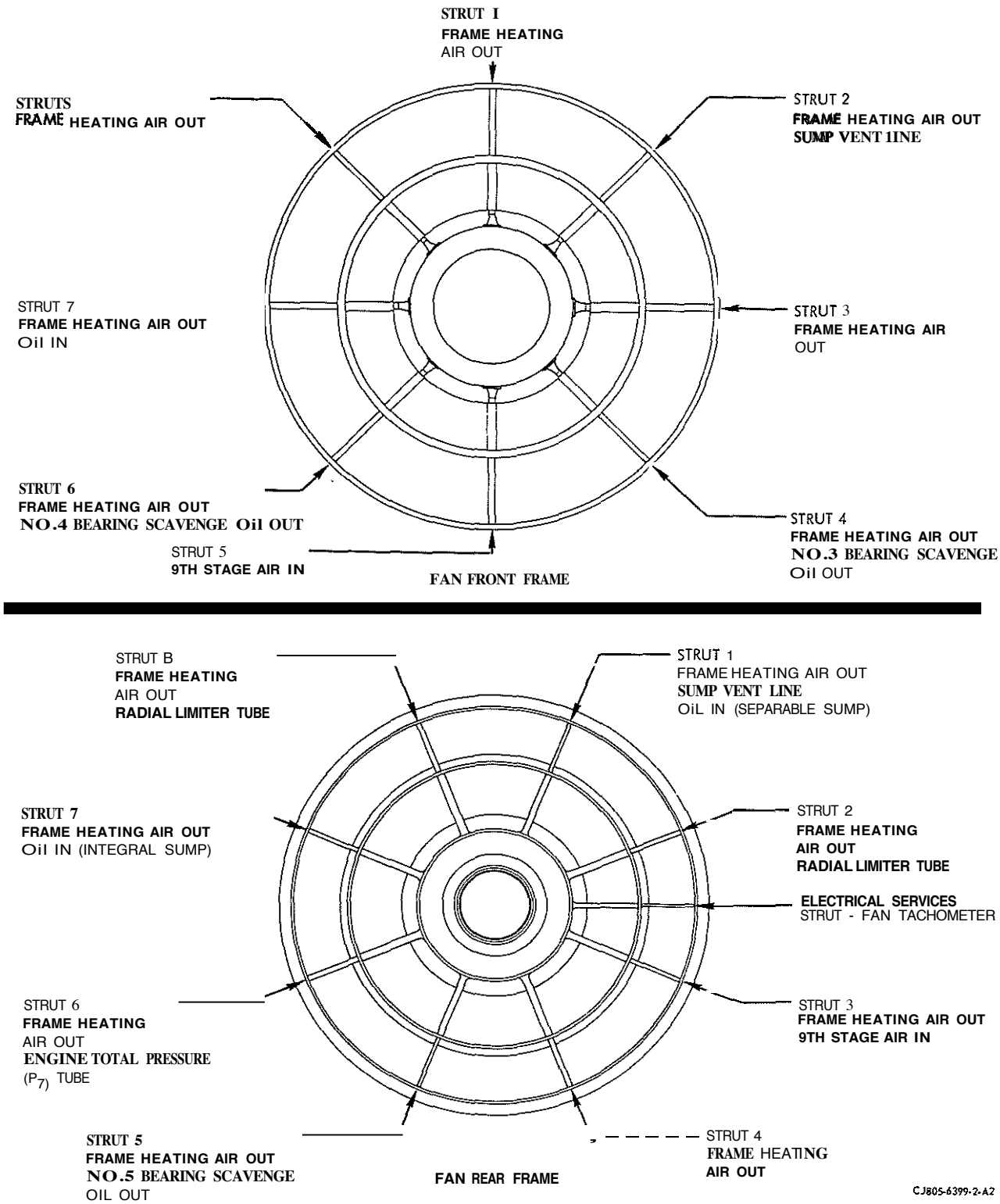
4. Fan Rotor. The fan rotor consists of a disc, 54 compound blades and 2 shafts; all of which are machined steel forgings. The compound blades consist of 2 airfoil sections separated by a dividing platform. They are installed into

dovetail slots in the outer rim of the disc. Projections on the mid-platforms interlock the blades to reduce deflection. Serrations on the front and rear sides of the blade mid-platforms mate with honeycomb seals installed in the fan frames to keep the 2 air-streams separate. The conical shafts are attached to the disc by rabbets and bolts.

5. Fan Rear Frame. The fan rear frame is a welded and riveted sheet metal construction. It consists of an outer shell, an intermediate and an inner skin and 8 equally-spaced struts. The frame is constructed to form 2 concentric, annular-flow air passages. The outer skin has 2 heating manifolds which receive primary airflow through 4 hollow struts to heat the outer skin, reducing thermal stress created by the temperature difference of the 2 air-streams passing through the frame. The manifolds also act as radial strengthening members for the frame. The No. 5 bearing, with its associated air and oil seals, is located in the frame inner hub. The fan tachometer generator and the No. 5 bearing scavenge pump are mounted on the rear side of the inner hub. The outlet gUide Vane is bolted to the front intermediate and outer flanges of the frame, with the rear axial air seal support bolted to the frame over the outlet guide vane inner flange.

6. Operation. The fan assembly is bolted to the turbine stator casing rear flange. It consists of a single-stage free-floating rotor, which is part compressor and part turbine; and a front and rear frame incorporating concentric annUlar-flow passages. Gases floWing to the rear from the turbine section flow into the inner passage of the fan front frame and through the partitions of the fan turbine nozzle. The nozzle directs the gases, at the correct angle of attack, onto the turbine airfoils of the fan rotor blades. The gases impart energy to the blades to drive the fan rotor and then flow through the inner passage of the fan rear frame and into the exhaust section. Secondary air is ducted into the fan inlet, the outer air passage of the fan front frame, and flows through the outer sections, compressor airfoils, of the fan rotor blades. The air then flows through a row of outlet guide vanes. which straighten the direction of flow, and through the outer passage of the fan rear frame to the exhaust section.

The fan front frame forms the air inlet of the fan section. The frame hub houses and supports the No. 3 bearing, which supports the rear shaft of the turbine rotor, and the No. 4 bearing, which supports the front shaft of the fan rotor. A linkpin boss at the top portion of the outer shell is used for mounting the engine in an airframe or ground handling equipment. Vertical and side loads are transmitted to the aircraft structure through the linkpin adapters. Oil to lubricate the No.3 and No.4 bearings is routed in through strut No.7 of the front frame. (See figure 2.) One nozzle assembly containing 2 spray jets distributes the oil over the No. 3 bearing, and a 3-jet nozzle assembly distributes the oil to the No.4 bearing. Oil is scavenged from the No. 3 bearing sump through strut No.4, and through strut No. 6 from the No. 4 bearing sump. Ninth-stage compressor bleed air is routed into the sumps through strut No. 5 and vented to the engine oil tank through strut No.2. This air is used to establish the proper pressure differential across the bearing seals, thus reducing oil loss and providing a positive pressure head to the scavenge pumps.



Fan Frame Strut Usage
Figure 2

A portion of the primary exhaust gas is bled through holes in the strut fairings and flows into the "hat" sections in the intermediate skin. Here the air serves a heating function, then flows into manifolds at the front and rear of the struts. From the manifolds the air flows outward through cored passages in the leading and trailing edges of the struts, except tbe top and bottom strut. The air anti-ices the struts and is vented through 2 holes at the outer ends of the struts into the secondary air stream. The top and bottom struts do not require anti-icing, since they are enclosed by the airframe-furnished inlet duct fairing. Seventh-stage compressor bleed air, which flows through the center of the turbine rotor rear shaft, is routed out through the center of all struts except strut No. 5 into the 2 "hat" sections on the outer skin. The air heats the frame, decreasing the amount of thermal stress created by the difference of approximately lOOOoF in temperature of the 2 air-flows through the frame. The air is discharged through holes in the outer shell into the secondary air stream. The 2 "hat" sections, in addition to serving as air manifolds, provide radial stiffness for the frame.

The fan rear frame serves as a diffuser passage for the primary and secondary air-streams. It is also the rear support structure of the engine, since the No. 5 bearing which supports the rear shaft of the fan rotor is housed in the frame. Oil to lubricate the No. 5 bearing is routed into the bearing housing through strut No. 7 or No. 1 and scavenged through strut No.5. (See figure 2.) Ninth-stage air to pressurize the bearing sump flows through strut No.3 and is vented to the oil tank through strut No.1. A portion of the discharge gases from the turbine section of the fan rotor is bled through holes in the strut fairings. This air flows outward through 4 struts into 2 heating manifolds around the circumference of the outer skin. This air heats the outer skin, reducing the thermal stress created by the temperature difference of the 2 air-streams passing through the frame. The air bleeds through the slots in the manifolds into the rear nacelle section. The manifolds, in addition to serving as air passages, provide radial stiffness for the frame. A small strut is assembled at the 3 o'clock position, between struts No. 2 and No. 3 and immediately to the rear of the frame struts. The electrical lead from the fan tachometer generator is routed to the frame outer shell through this strut. Radial limiter tubes (part of power reduction system) are located in struts Nos. 2 and 8. The engine total pressure probe (P7) tube is located in strut No.6.

FAN FRONT FRAME - MAINTENANCE PRACTICES

1. Inspection/Check. Inspect visually. Confirm suspected cracks using spot **fluorescent-penetrant inspection. Accept any number of cracks not exceed.ing** 1/16 inch in length anywhere on the part provided they will not cause air or fluid leakage. Transverse cracks in welds, exceeding 1/16 inch in length, must not extend into parent metal and. must be at least 1/2 inch apart.

Inspect/Check	**Maximum Serviceable Limit**	Remarks
A. Fan front frame for:		
(1) Cracks in flange bolt holes	1 per hole radially outward, minimum separation of 4 holes	
(2) Cracks in flange to outer skin welds	Not serviceable	
(3) Cracks in hat **sections within** 1 inch of strut support	**Not serviceable**	
(4) Cracks in hat **sections more than** 1 inch from strut support	Any number up to 1/4 inch in bleed holes	
(5) Cracks in outer strut supports and support welds	Not serviceable	
(6) Cracks in all **other areas of outer casing**	**Not serviceable**	
(7) Nicks, dents, **gouges, etc.** not in flange mating face	1/16 inch deep, 1 inch long, provided metal is not thinned to less than 75% of original thickness	
(8) Cracks in outer **liner**	1/2 inch long, 2 inch cumulative length, minimum of 4 inches be- **tween cracks and from corners**	
(9) Missing rivets	**10 per outer casing, maximum of 3 in anyone liner segment**	

Inspect/Check	Maximum Serviceable Limit	Remarks
(10) Cracks in struts	Not serviceable	
B. Insulation blankets on outside of frame for:		
(1) Damage	Moderate damage is allowed provided no more than 10% of **insulation material is missing**	
(2) Insulation lockwiring	Blankets must be securely lockwired	

CAUTION: EXHAUST GASES FROM REVERSE THRUST OPERATION WILL SEVERELY DAMAGE THE INSULATION BLANKETS IF THEY ARE NOT PROPERLY SECURED.

C. Upper and lower fan pylons for:		
(1) Cracks	Any number emanating from rivet holes, 1/4 inch long not in adjacent holes	
(2) Loose or **missing rivets**	Not serviceable	
(3) Foreign object damage	Not serviceable	
D. Fan adapter shrouds and circular air deflector for:		
(1) Cracks	Any number, 3/8 inch long emanating from the slot in the front corner of the adapter shroud extension adjacent to the fan pylons.	
(2) Foreign object damage	Not serviceable	
E. Fan turbine nozzle for:		

NOTE: Check the fan turbine nozzle by looking up the rear of the fan assembly, through the fan rotor blades.

(1) Cracks in inner band:		
(a) Axial within 1/8 inch of vane slot'weld	12 per nozzle 3/4 inch long	

Inspect/Check	Maximum Serviceable Limit	Remarks
(b) Extending from vane slot trailing edge	Any number, 1/4 inch long	
(c) Extending from vane slot leading edge	Any number, 1/4 inch long	
(d) In baffle	6 per nozzle, 1 inch long	
(2) Inner band wear	0.020 inch thickness remaining	
(3) Cracks in outer band:		
(a) Axial between vanes	8 per nozzle, 1/2 inch long	
(b) Extending from vane slot trailing edge	Any number, 3/16 inch long	
(c) Outer band to flange weld	4 per nozzle, 1/2 inch long	
(4) Gouges in outer band	Any number, 0.020 inch deep after removal of high metal	
(5) Dents in outer band	Any number 0.100 inch deep	
(6) Cracks in vanes:		
(a) Radial in trailing edge	4 per nozzle, 2 per vane, 1/2 inch long	
(b) Axial in trailing edge	10 per nozzle, 2 per vane, 1/2 inch long	
(c) Axial at outer end of vane body	4 per nozzle, 1 per vane, 1/2 inch long	
(d) Elsewhere in vane body	12 per nozzle, 2 per vane, 3/8 inch long	
(7) Nicks, gouges, etc. in vanes	Any number, 0.020 inch deep	

Inspect/Check	Maximum Serviceable Limit	Remarks
(8) Dents in vanes	Any number, 1/16 inch deep, 1/8 inch in diameter and/or 5 per vane, 1/8 inch deep	
(9) Vane buckling		
(a) In leading edge	3/32 inch as checked by a straight edge against the leading edge provided vane **is not burned or cracked in** the buckled area	
(b) In trailing edge	3/16 inch as checked by a straight edge against the trailing edge provided vane **is not burned or cracked in** the buckled area	

2. Approved Repair.

A. Remove high metal from external tube flanges, exposed tubes, all areas in the secondary air-stream passage and the fan turbine nozzle.

B. Chase threads as required to repair thread damage.

C. Tighten or replace loose or missing rivets.

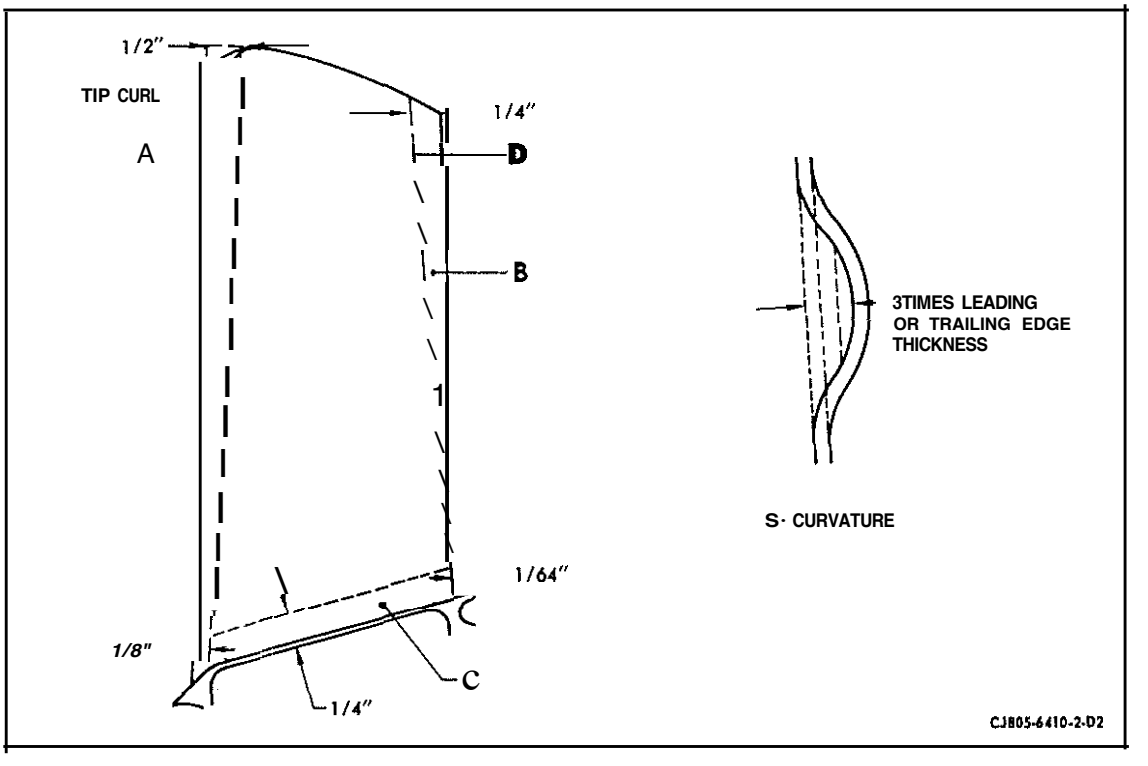
D. Re-lockwire or replace loose or excessively damaged insulation blankets.

E. Blend burned turbine nozzle partitions to the base of the burn. Do not exceed 0.020 inch in depth.

F. If the above repairs do not return the part to within serviceable limits, or if any other serviceable limits for the part are exceeded, remove the engine and return the part to overhaul.

FAN ROTOR - MAINTENANCE PRACTICES

1. **General.** **The maintenance of the fan rotor is limited to the secondary air-**foil portion which can be reached through either the engine inlet or exhaust openings and trailing edge of the primary airfoil which may be reached through the exhaust opening. Some inspection of the leading edge of the primary airfoil may be possible through the exhaust opening.



Secondary Airfoil Inspection
Figure 201

2. Inspection and Checks

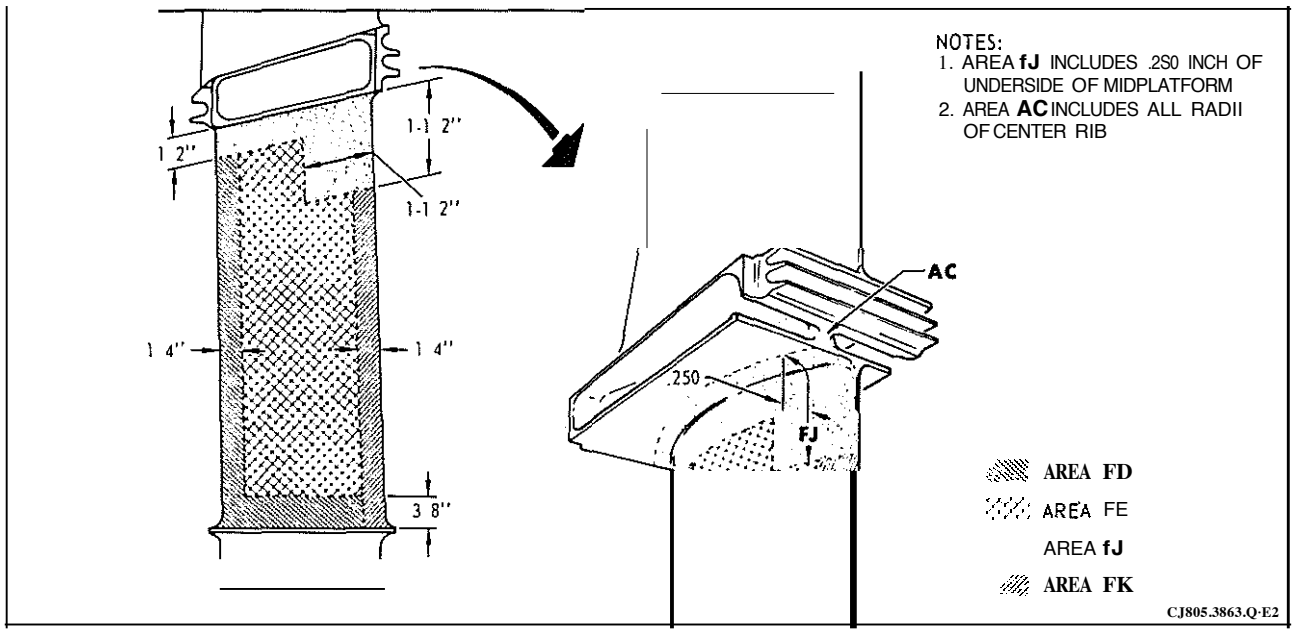
A. Check/inspect secondary airfoil portion of the fan rotor blades for the following damage: (See figure 201.)

Inspect	Maximum Serviceable Limits	**Maximum** Repairable Limits	Repair Method
(1) All areas for cracks			
(a) Caused by impact damage or **cold rework**	Not serviceable	Must be completely removed by blending **and not exceed repair** limits for dents of that area	Blend.

Inspect	Maximum Serviceable Limit	Maximum Repairable Limit	Repair Method
(b) From other causes	Not serviceable	Not repairable	
(2) Leading and trailing edge tips for **curling or out of contour**	1/4 inch long	Any amount within 2-1/2 inch of end of blade on the leading edge or 1-3/4 inch of trailing edge. Any **resulting cracks from reforming, see inspection for cracks**	Reform by cold rework or blend.
(3) Leading and trailing edges for **S-curvature**	Displacement from straight edge by 3 times the edge thickness	Any amount within 2-1/2 inches of end of blade on the lead-edge or 1-3/4 inch on the trailing edge	Straighten **using pliers** with brass jaws 112 **inch min.** width.
(4) Leading edge, Area A, defects originating from edge radius:			
(a) Nicks, dents and pits	1/32 inch depth **from original contour, minimum separation** of 1/8 inch	Within the confines of Area A.	Blend.
(b) Scratches	**Not serviceable**	Local blend on edge within the confines of Area A.	Blend.
(5) Leading edge, Area A, airfoil surfaces for:			
(a) Nicks, dents and pits	0;015 inch depth, **minimum separation** of 1/8 inch	20 percent of blade thickness but not more than 0.020 inch deep **in airfoil surface, or** local blend edge with-**in the confines of** Area A.	Blend.
(b) Scratches	**Not serviceable**	20 percent of blade **thickness but not more** than 0.020 inch deep **in airfoil surface,** or local blend edge within the confines of Area A	Blend.

Inspect	Maximum Serviceable Limit	Maximum Repairable Limit	Repair Mej:hod
(6) Trailing edge, Area B, defects originating from edge radius:			
(a) Nicks, dents, pits and scratches	0.005 inch depth, minimum separation of 1/8 inch	Within confines of Area B	Blend.
(7) Trailing edge, Area B, airfoil surfaces for:			
(a) Nicks, dents, pits and scratches	0.005 inch depth, minimum separation of *1/8* inch	20 percent of blade thickness but not more than 0.020 inch deep in airfoil surface, or local blend edge within the confines of Area B	Blend.
(8) Airfoil, Area D, for:			
(a) Nicks, dents and pits	0.015 inch depth, minimum separation of *1/8* inch	20 percent of blade thickness but not more than 0.020 inch deep, 0.400 inch long but not more than 5 per square inch	Blend.
(b) Scratches	Not serviceable	20 percent of blade thickness but not more than 0.020 inch deep, 0.400 inch long but not more than 5 per square inch	Blend.
(9) Airfoil, Root Area C, for:			
(a) Nicks, dents and pits	0.005 inch depth, minimum separation of *1/8* inch	0.010 inch deep	Blend.
(b) Scratches	Not serviceable	0.005 inch deep	Blend.

B. Visually check the primary airfoil portion of the fan rotor blades for the following damage. (See figure 201A.)



Primary Airfoil Inspection Areas
Figure 201A

Inspect	Maximum Serviceable Limit	Maximum Repairable Limit	Repair Method
(1) Cracks in any **area**	**Not serviceable**	Not repairable	Replace **engine.**
(2) Mid-platform, Area AC, for:			
(a) Nicks, dents, pits and **scratches**	**Not serviceable**	Not repairable	Replace **engine.**
(3) Area FD for:			
(a) Nicks, dents and pits	0.006 inch depth, **maximum of 10 and minimum separation** of 1/8 inch	Not repairable	Replace **engine.**
(b) Scratches	**Not serviceable**	Not repairable	Replace **engine.**
(4) Airfoil, Area FE, for:			
(a) Nicks, dents and pits	0.010 inch depth, maximum of 15 and **minimum separation** of 1/8 inch	Not repairable	Replace **engine.**

Inspect	Maximum Serviceable Limit	Maximum Repairable Limit	Repair Method
(b) Scratches	**Not serviceable**	Not repairable	Replace **engine.**
(5) Area FJ for:			
(a) Nicks, dents, pits and **scratches**	Not serviceable	Not repairable	Replace **engine.**
(6) Area FK for:			
(a) Nicks, dents and pits	0.003 inch depth, **maximum of 4 and minimum separation** of 1/4 inch	Not repairable	Replace **engine.**
(b) Scratches	**Not serv.iceable**	Not repairable	Replace **engine.**

C. Check the mid-platform for protruding pieces of interlock air seals. **Remove protruding pieces. Any number of air seals may be missing provided fan speed is within limits.**

3. Repair Procedures.

A. General.

NOTE: These procedures are based on "hand" rework methods because of the necessity to eliminate the stresses that may be produced by **"power" rework. "Power" rework (rework by power-driven devices) on any of the primary airfoil or any of the critical area of the secondary airfoil requires heat-treating to eliminate stresses and therefore cannot be used as a maintenance technique. However "power" rework may be used on the non-critical area of secondary airfoil without heat-treating and may be desirable for maintenance** repair in that area. Refer to figure 203 for critical and non-**critical areas of the secondary airfoil.**

(1) Do not attempt to straighten dents or bends in the primary airfoil or the lower half of the secondary airfoil because the condition may be aggravated.

(2) Rework only enough material to eliminate evidence of injury. How-**ever, the rework must be extensive enough to completely remove the injury.**

(3) Material removal and polishing should be accomplished using a longitUdinal motion of the file, stone or emery cloth.

(4) Use a file or emery cloth to remove nicks and dents when removal of large quantities of material is necessary. File parallel to blade edge.

NOTE: Use a file only on the leading or trailing edges of tip corners.

(5) Use a medium abrasive stone to smooth areas previously reworked with a file or emery cloth or on areas containing small nicks and dents.

(6) If the ends of two or more local blends come within one inch of each other, remove the protruding material between them.

(7) When stock is removed from the leading or trailing edge, the new edge must be rounded to a smooth radius.

B. Rework to Correct Rotor Unbalance Caused by Removal of Blade Damage.

NOTE: Removal of material will effect the balance of the fan rotor. The limits and method of compensating for major rework are based upon the actual material removed and does not take into consideration any effect of distortion, caused by major foreign object damage, upon balance.

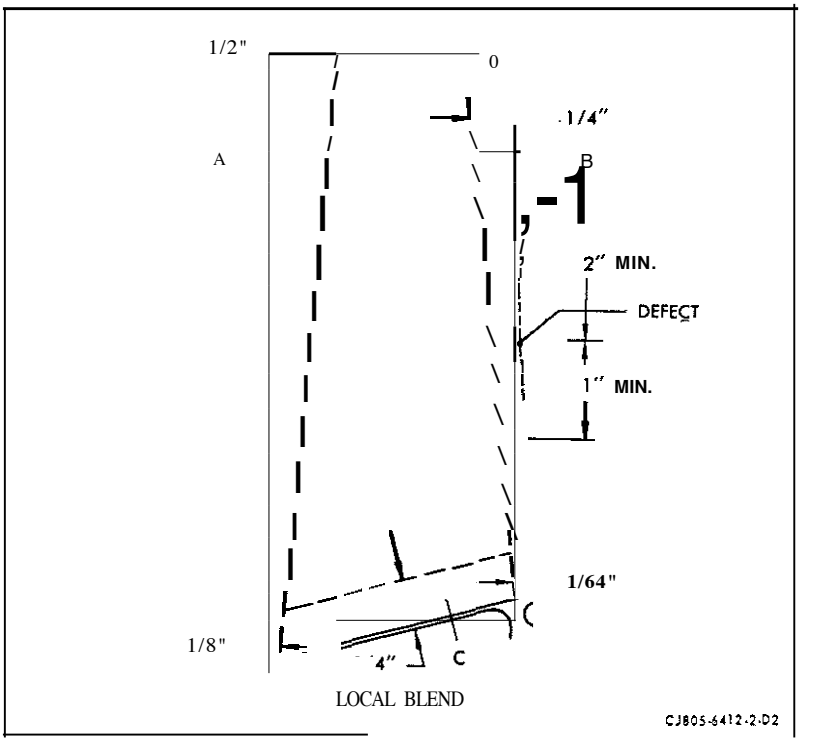
(1) Rework not requiring balance compensation.

(a) A maximum of 0.100 inch taper blend (leading edge) or 0.033 taper blend each for three blades .is allowable without compensating rework.

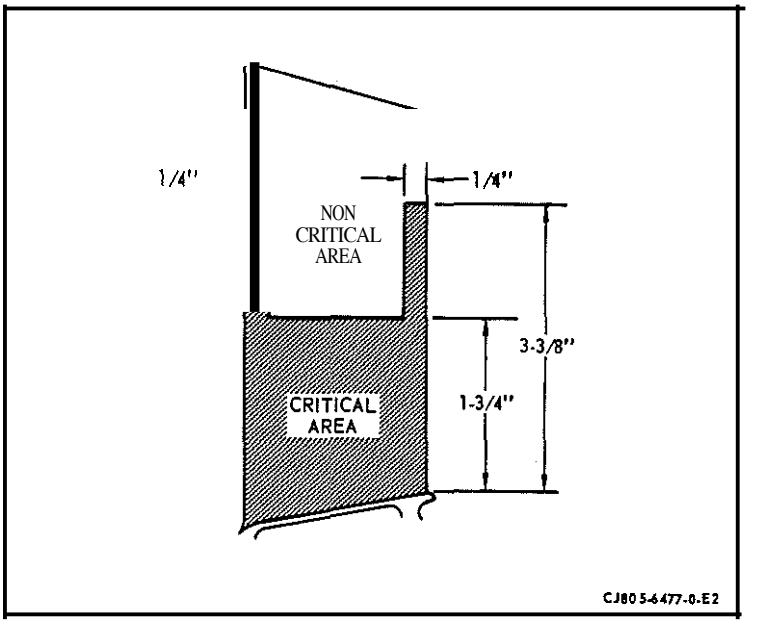
(b) A maximum leading edge local blend or blends totaling 0.200 x 3 inches (see figure 202) for one blade or 0.066 x 3 inches for any three consecutive blades is allowable without compensating rework.

(2) Rework requiring balance compensation.

Any blending exceeding the above limits must be compensated for by identical blending of a blade (or blades) located 180 degrees from the reworked blade. A maximum of 10 blades (pairs of blades) may be reworked in this manner, beyond 10 the effect on balance becomes critical.



Secondary Airfoil Repair
Figure 202



Secondary Airfoil Critical Areas
Figure 203

C. Rework of Secondary Airfoil Contour.

(1) Deburring or removing scratches from the airfoil contours (sections C or D of figure 202) should be accomplished using emery cloth and/or fine abrasive stones.

(2) Do not attempt to rework the protrusion on the opposite side of the injury.

D. Blade Tip Corner Repair.

(1) On blades where rework of both leading and trailing edges or only one edge require blending do not exceed a blend radius of 1/2 inch.

(2) If the curl is still apparent after 1/2 inch blend radius is reached, a residual curl of 1/8 inch radius is permissible.

E. Secondary Airfoil Root Area Repair Leading and Trailing Edges (Areas A and B, figure 202).

(1) Remove damage by forming a smooth surface, as nearly like the original configuration as possible from blade base to 2 inches above damage by blending being careful to form a smooth curve at the base no less than 3/16 inch radius at the base.

(2) Depth of removal should not exceed the limits for that area (Area A or B).

F. Secondary Airfoil Leading and Trailing Edge Repair (Areas A and B, figure 202).

(1) Leading or trailing edge damage may be repaired by removal of material in a long local blend beginning 1 inch below the defect, removing all the damaged area and then extending above this point at least 2 inches or to the blade tip, whichever is closer.

(2) Depth of removal should not exceed the limits for that area (Area A or B).

G. Primary Airfoil Root Area Repair, Leading and Trailing Edges.

(1) Remove damage by forming a smooth surface as nearly like the original configuration as possible from blade base to 2 inches above defect by blending. Be careful to form a smooth curve at the base or the mid-platform no less than 3/16 inch radius.

H. Primary Airfoil Leading and Trailing Edge Repair.

(1) Leading or trailing edge damage may be repaired by removal of material in a long local blend beginning 1 inch below the defect, removing all the defective area and then extending above this point 2 inches or to the bottom of the mid-platform whichever is closer.

FAN ROTOR SHROUD - MAINTENANCE PRACTICES

1. Inspection/Check. Visually inspect the areas listed.

Inspect/Check	Maximum Serviceable Limit	Remarks
A. Check the epoxy resin surface for:		
(1) Tears, gouges	3/8 inch wide, separated by 1/2 inch of good epoxy; 20 inch cumulative length	
(2) Craters	3/4 inch diameter, 1/8 inch deep separated by 1/2 inch of good epoxy	
(3) Wear	Any amount, provided maximum shroud-blade tip clearance can be met	
(4) Axial cracks	Any amount, minimum separation of 4 inches from all other cracks	
(5) Circumferential cracks	3 inches long, 10 inch cumulative length, minimum separation of 4 inches from all other cracks	

2. Approved Repair. If the serviceable limits are exceeded, the engine must be removed and the fan rotor shroud returned to overhaul.

Inspection/Check. Visually inspect the areas listed. Confirm suspected cracks using spot fluorescent-penetrant per 89-1-8.

Inspect/Check	Maximum Serviceable Limit	Remarks
A. Outer casing for:		
(1) Cracks in mounting flange bolt holes	16 radially outward, minimum separation of 4 bolt holes	
(2) Cracks anywhere in outer casing including hat sections except at forward flange weld or within 1 inch of an outer strut support	3/8 inch long, minimum separation of 6 inches; 2 inch total cumulative length	
(3) Dents, nicks and gouges anywhere in casing including hat sections, except at forward flange weld or within 1 inch of an outer strut support	1/16 inch deep, 1 inch long with no metal thinning below 75% of original thickness; 10 inch total cumulative length	
(4) Missing rivets anywhere on frame	Maximum of 6 separated by 6 serviceable rivets	
(5) Cracks in outer liner except at rivet holes	1/2 inch long, minimum separation of 4 inches from corners and. from other cracks	
(6) Cracks in thrust reverser latch mount and latch mount welds	Not serviceable	
(7) Cracks in exposed tubes, tube flanges, tube joints, and tube flange welds	Not serviceable	

Inspect/Check	Maximum Serviceable Limit	Remarks
B. Mid casing for:		
(1) Cracks in area 6 inches wide aft of each strut, or within 1 inch of a mid strut support	Not serviceable	
(2) Cracks in other areas of mid casing	1/2 inch long, minimum separation of 6 inches, 4 inch total cumulative length	
(3) Nicks and gouges	Any number 1/64 inch deep, after removal of high metal	
(4) Cracks in mid casing mounting flange bolt holes	10 radially outward, not in adjacent holes	
C. Gas passage liner assembly for:		
NaI'E: The gas passage liner assembly consists of the mid liner, strut fairings and inner liner.		
(1) Nicks, dents, gouges and bulges	1/8 inch deep, 1 inch diameter, minimum separation of 6 inches with no metal thinning below 75% of original thickness; 10 inch total cumulative length	
(2) Cracks	1/2 inch long, minimum separation of 4 inches, 10 inch total cumulative length	
(3) PT7 probe boss for:		
(a) Coke or carbon deposit	Not serviceable	Clean and polish to smooth finish, square with threaded hole
(b) Nicks, dents and gouges	0.010 inch deep, 0.062 inch long. Boss must be capable of being sealed	

Inspect/Check	Maximum Serviceable Limit	Remarks
(c) Thread damage	1 1/2 threads after chasing threads	
D. Struts (including airfoil portion of strut support) for:		
(1) Cracks in parent metal and welds	**Not serviceable**	
(2) Nicks and gouges	Any number, 1/64 inch deep after removal of high metal	
E. Missing shank nuts **anywhere on frame**	**Not serviceable**	
F. Insulation blankets around outside of frame for:		
(1) Damage	Moderate damage is allowed provided no more than 10% **of material is missing**	
(2) Security of blankets	Blankets must be securely bolted in place	
CAUTION: EXHAUST GASES FROM REVERSE THRUST OPERATION WILL SEVERLY DAMAGE THE BLANKETS IF THEY ARE NOT PROPERLY SECURED.		
G. Total pressure probe tUbe (strut No.6) for leaks	No leakage allowed	
H. Outlet guide vane assembly for:		
(1) Cracks in **all areas**	Any **number,** 1/8 inch long, **minimum** separation of 4 **inches**	
(2) Cracks in **inner** band	1/2 **inch** long, 5 inch total **cumulative** length, **minimum separation** of 6 **inches**	
(3) Cracks in **outer** band	1/2 **inch long,** 5 inch total **cumulative** length, **minimum separation** of 6 **inches**	
(4) Dents **inner** or **outer** band	Any number of **smooth contour dents,** 1/16 **inch in** depth with no thinning of parent metal	

Inspect/Check	Maximum Serviceable Limit	Remarks
(5) Cracks in vanes	1 per vane, 1/4 inch long, **separated by 3 sound. vanes**	Refer to paragraph 2.F.
(6) Missing vanes	**Maximum of 1 missing vane** per assembly	
(7) Dents in vanes	1 smooth contour dent per vane, 1/8 inch deep	
(8) Looseness of vane in band on Type piN 638E320 and 638E591	Total movement of 0.080 inch **circumferential or axial**	

2. Approved Repair.

A. Remove high metal from external tube flanges, exposed tubes, all areas **in the primary and secondary air-stream passages, the outlet guide vane** assembly and the No. 5 sump mating flanges.

B. Chase threads as required to repair thread damage.

C. Tighten or replace loose or missing rivets.

D. Re-torque or replace the bolts which secure the insulation blankets around the outside of the frame.

E. Repair of cracks in doublers on intermediate skin.

(1) Weld per A-286 weld procedure 89-1-3, paragraph 9, and. the following **information:**

(a) Flood the rear side of the weld with argon gas at approximately 10-15 cubic feet per hour.

(b) If repair extends to the edge of the doubler, the doubler will be welded to the intermediate skin in this area.

(c) Weld height not to exceed 0.060 inch.

F. If cracks in vanes exceed the serviceable limit, one vane per assembly may be removed. Cut away vane to within 1/4 inch of inner and outer **bands.**

CHAPTER 73 - FUEL AND CONTROL SYSTEM

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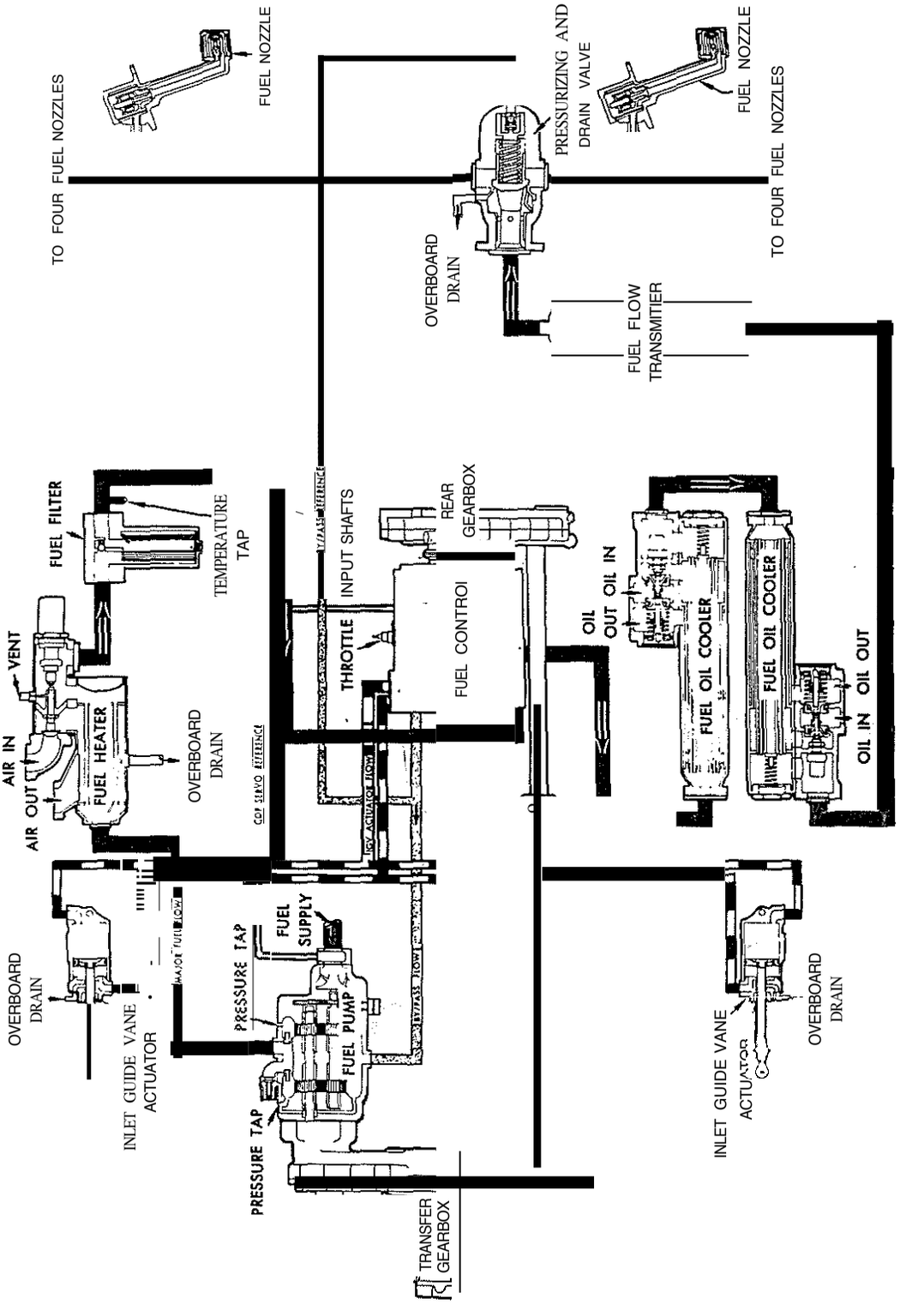
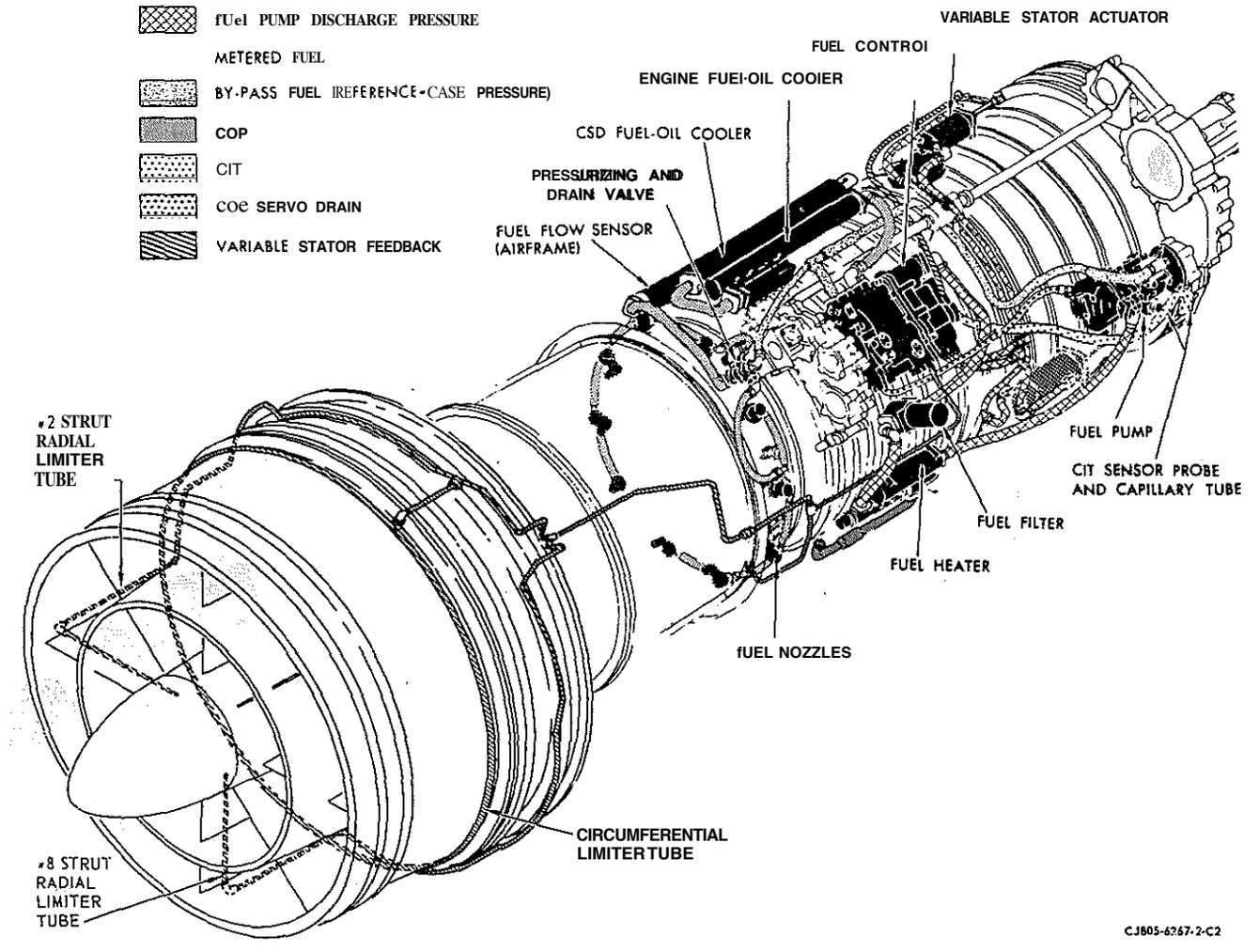


Fuel and control System Schematic Diagram
Figure 1

1. General. The fuel and control system is a hydro-mechanical system. Its **prime functions are to meter fuel and adjust airflow for all engine operations. The system, in a secondary capacity, provides fuel as a hydraulic fluid for variable vane actuation and as a coolant for scavenge oil.**

2. System Description. Figure 1 shows the system and the relation of the components in the flow path. The routing of lines and the location of the components on the engine are shown in figure 2. The following list gives the function and location of each component.



FUel and Control System (Engine View)
Figure 2

Component	FUnction	Location
FUel Pump	**Receives fuel at low pressure from** the airframe supply and discharges fuel at high pressure to the fuel **heater.**	**7 o'clock on rear face of transfer gearbox.**

Component	Function	Location
Fuel Heater	Receives fuel from the pump and discharges to the fuel filter. Seventeenth-stage compressor air is used to heat the fuel whenever fuel icing conditions exist.	8 o'clock on compressor rear stator casing.
Fuel Filter	Receives fuel from the heater, filters the fuel and discharges it to the fuel control. Fuel is bypassed if the filter elements become clogged.	7 o'clock on compressor rear stator casing.
Fuel Control	Receives fuel at about pump discharge pressure. Meters fuel as a function of throttle angle, rpm, compressor discharge pressure and compressor inlet temperature to control engine speed. Metered fuel is piped to the engine fuel-oil cooler. Excess fuel is bypassed to the fuel pump. The control also computes and properly adjusts the position of variable stators.	6 o'clock on front face of rear gearbox.
Engine Fuel-Dil Cooler	Receives fuel from the control and discharges fuel to the CSD fuel-oil cooler. Uses fuel flow to cool hot scavenge oil from the bearings and gearboxes. For further details, refer to Lubrication System.	4:30 o'clock on compressor rear stator casing.
Constant Speed Drive Fuel-Oil Cooler	Receives fuel from the engine fuel-oil cooler and discharges fuel to the fuel flow sensor. Uses fuel to cool hot oil from the constant speed drive and the thrust reverser system. For further details, refer to Lubrication System.	4 o'clock on compressor rear stator casing.
Fuel Flow Sensor	Provisions have been made for mounting a fuel flow sensor (airframe furnished) in the fuel line between the CSD fuel-oil cooler and the pressurizing and drain (P & D) valve. The short section of fuel line supplied by General Electric is removed when the sensor is substituted. (Refer to Chapter 71 in Aircraft Maintenance Manual.)	3:30 o'clock on compressor rear stator casing.

Component	Function	Location
Pressurizing and Drain Valve	Receives fuel from fuel flow sensor and discharges fuel to fuel nozzles. The valve drains the fuel manifold at shutdown.	6 o'clock on rear flange of lube and scavenge pump.
Fuel Nozzles	Receives metered fuel from the pressurizing and drain valve and spray fuel into the 10 combustion liners.	10 nozzles equally spaced around the engine at the compressor rear frame.
Variable stator Actuators	Hydraulically driven by fuel from servo section in the fuel control. Actuator movement is transmitted by bellcranks to the variable stators.	4:30 o'clock and 11 o'clock on compressor front stator casing.
Variable Stator Reset Mechanism	Hydraulically actuated by signal from thrust reverser pilot valve. When actuated this assembly calls for the variable stators to reset in a closed position.	On variable stator feedback shaft of fuel control.

3. System Control Signals. To provide proper engine operation, signals representing the pilot's requirements and the engine operating conditions are fed to the fuel control. The following is a list of the signals and their functions.

Signal	Function
Throttle Position	Fed to the control through aircraft linkage and represents the pilot's demand for a specific engine rpm.
Engine Speed	Sensed through the control drive shaft that is splined into the rear gearbox of the engine. It is used to schedule fuel flow and variable vane position.
Fuel Shut-Off Lever Position	Actuates the fuel shut-off valve in the control. Provides a positive shut-off independent of throttle position.
Compressor Discharge Pressure (CDP)	Indicates the amount of air available for combustion. It is used in conjunction with the other parameters to determine acceleration schedule and is used by itself to set the deceleration schedule.
Compressor Inlet Temperature (CIT)	Indicates temperature of incoming air. It is used to determine acceleration and variable vane position schedules.
Variable Vane Feedback	Indicates actual position of variable vanes. It is compared to desired vane position to determine the flow of fuel pressure to the variable stator actuators.

Signal	Function
Engine power reduction signal	**An arrangement of tubes, containing compressor discharge air, which will reduce fuel flow to less than idle requirements if a blucket failure endangers the structure of the fan.**

4. System Operation. During engine operation the system if operating properly, demonstrates certain normal operating characteristics. These characteristics and the control signals that combine to cause them are reviewed in the following paragraphs.

A. Start: Air-motoring the engine actuates the engine fuel pump, and pump discharge pressure rises. Fuel flows to the control and returns to the pump through the bypass line, while operating pressures develop in the fuel control. Advancing the fuel shutoff lever opens the fuel shutoff valve in the discharge section of the control, and metered fuel flows to the pressurizing and drain valve.

If the engine has been started previously, the line between the fuel control and the pressurizing and drain valve (P & D valve) is already primed. Metered fuel pressure at the P & D valve increases until it overcomes the force of reference pressure plus spring force. The valve then opens, and fuel continues to the fuel nozzles. During a start the variable stators are closed.

Fuel flow during the start is at least 500 pph with standard combustors and 615 pph with low smoke combustors. The exact flow varies because of CIT, CDP and engine speed, but it is primarily a function of CDP. On cooler days a CIT signal reflects the temperature drop, the greater air density and the higher weight flow through the compressor at a given rpm. The control reacts by metering a slightly higher starting fuel schedule to match the heavier weight flow. As air-motoring increases engine speed, CDP becomes greater and promotes a higher starting fuel flow. Fuel flow rises rapidly to the limit set by CDP and continues to rise slowly as rpm and CDP increase.

During a normal light-off, exhaust gas temperature (EGT) rises sharply, peaks and drops slowly as .the engine automatically accelerates to IDLE. During a hot start, the EGT peak exceeds the maximum peak limit or drops too slowly, and is above the maximum temperature specified at 5, 10 or 15 seconds after light-off. This topic is presented in greater detail in the engine run-up procedure. (Refer to 72-0, Adjustment/Test.) The likelihood of a hot start increases as the engine continues to air-motor without a light-off, because both the rate of flow and the total fuel accumulation in the combustion section become greater. Hot starts are avoided by monitoring the time that expires after the first fuel flow indication and by aborting the start if no light-off occurs after a maximum period of time or at a maximum rpm. It is also necessary to monitor fuel flow during an engine start. The start is aborted if fuel flow exceeds 700 pph without a light-off.

B. Acceleration and Deceleration: During the start the throttle, even at its minimum position, is signaling for IDLE speed. The system senses both the actual rpm due to air-motoring and desired rpm which is much higher. At light-off a maximum acceleration fuel schedule is generated immediately to correct the off-speed condition. The exact rate of acceleration varies with the value of CDP and rpm at light-off, and CIT as well. Once again cold dense air reflected by a lower CIT results in a higher maximum fuel schedule and faster acceleration. During an ac-

celeration engine speed increases, the compressor performs more work and CDP increases. More air is available for burning, and fuel flow increases to the next point on the acceleration fuel schedule. This process is repeated until actual speed equals desired speed, and the fuel control governor decreases fuel flow to a value that sustains IDLE speed.

In a throttle burst above IDLE, the same sequence of events occurs, but at some point in the acceleration rpm and CIT form a predetermined combination and the variable stators start to open. The stators are fUlly opened before rpm reaches 100 percent but the full-open and full-closed points vary with CIT. In some cases (cold temperatures), the stators may start to open somewhat before IDLE.

The minimum fuel flow scheduled during a rapid deceleration is controlled by COP to prevent a lean fuel-air mixture in the combustion section. When the throttle is retarded, the fuel control governor senses that desired speed is now lower than actual speed. An initial decrease in fuel flow is followed by a drop in rpm, a lower COP and a further decrease in fuel flow.

C. Steady-State Operation: The system also relies upon the fuel control speed governor to remain at the correct performance point during steady-state operation. As engine environmental conditions change (altitude, airspeed, air temperature, etc.), the resultant change in loading of the compressor will cause a tendency for the rpm to change. The governor will sense these minor speed errors and instantaneously correct for them by adjusting metered fuel flow. Thus the desired steady-state condition will be maintained. However, when CIT decreases below certain limits, the governor, for safety purposes, is overridden if necessary to reschedule maximum rpm to lower values.

D. Take-Qff: When the throttle is advanced to the maximum stop, engine speed increases to 7684 rpm (103 per cent) except underconditions of low CIT as noted in item C. EGT also increases, and, if the 103 percent rpm results from a throttle burst, the EGT indicator should be monitored for any transient over-temperature condition. Higher speed increases mass air flow through the engine, and higher EGT increases exhaust gas velocity. Both factors result in more engine thrust.

E. Thrust Reverse: When the thrust reverse lever is moved to the THRUST REVERSE position, the control generates an acceleration fuel schedule. Acceleration time is controlled by the same factors at work during a forward throttle movement; but maximum thrust reverse speed is limited to 7460 rpm (100 percent). Thrust is reversed by a reverser sub-system which deflects the exhaust gases forward. The thrust reverser and its controls are described in Chapter 78, Exhaust System.

F. Shutdown: With the throttle at its minimum forward thrust position (IDLE), the engine is shut down by retarding the fuel shutoff lever to OFF. In emergencies the engine can be shut down with the throttle at any position. The shutoff valve in the fuel control closes as the shutoff lever is retarded to OFF. Operating pressures within the fuel con-

trol close the variable stators while fuel continues to circulate between the fuel pump and the control as engine speed coasts down. But flow to the nozzles is cut off. Fuel pressure drops in the major fuel line and spring force in the P & D valve closes the valve, leaving the fuel line primed for the next start. Fuel between the P & D valve and the fuel nozzles drains through the drain port of the P & D valve. Fuel also drains from the combustion section.

G. Fan Control: The fan rotor is aerodynamically coupled to the engine rotors so that any change in engine speed results in a predetermined percentage change in fan rotor speed. During operation, there is a close correlation between fan speed and engine speed. That is, the fan rotor and engine rotors reach the same performance point in approximately the same time with little or no fan speed overshoot or hunting. Fan rotor speed lags engine speed percentage-wise at low speed points. For example, at engine IDLE (60 percent), fan rotor speed is approximately 23 percent. This speed mismatch is overcome above approximately 80 percent. If an emergency condition were to occur in which the fan rotor attempted to overspeed, retarding the throttle to idle or, in an extreme case, shutting down the engine, would keep fan rotor speed within limits. However, under normal operating conditions, fan rotor speed will not exceed the maximum limits.

H. Engine Power Reduction System: The system consists of an arrangement of tUbes carrying compressor discharge air and manifolded to the CDP sensing line of the main fuel control. A rupture of anyone of the tubes will dump CDP which is sensed by the main fuel control. This in turn will reschedule the main fuel to less than idle requirements. The arrangement of tubes consists of one mounted circumferentially on the fan front frame outer skin and two located radially in struts 2 and 8 in the fan rear frame. The circumferential tUbe will be effected by a blucket root failure. The radial tubes are designed to fail as a result of tensile loading, induced by high amplitude deflection of the fan rear frame hub relative to the outer skin. This high amplitude is caused by fan rotor unbalance resulting from blucket loss. If there is strut failure at the hub joints, high tensile loads will be imposed on the tubes.

FUEL AND CONTROL SYSTEM - TROUBLE-SHOOTING

1. General. Visual checks are important when trouble-shooting the fuel and control system, because small defects in mechanical, hydraulic or pneumatic signal lines can affect the fuel flow schedule. A mistaken notion that the fuel control must be changed later becomes a disappointment when the engine is run-up, and the malfunction persists despite the new fuel control. Perform operational checks whenever possible, to identify all available symptoms of the malfunction. The test facilities, spare parts on hand, type of malfunction and the importance of time usually determine how much testing and investigation precedes the decision to replace a component. An obvious symptom such as a pressurizing and drain valve that does not drain at shutdown, requires little testing or analysis before the "fix" is established. Acceleration problems are in a more difficult category, and special tests are almost a necessity.

   Trouble-Shooting table is furnished in Section 72-0.

4. High Starting Fuel Flow.

Possible Cause	Isolation Procedure	Correction
A. Faulty CIT sensor	Check variable vane schedule and plot curve. (Refer to 72-0, Adjustment/Test.) 1. If parallel to schedule, but above or below by more than tolerance, sensor is faulty. 2. If curves tend to intersect so that the schedule exceeds tracking check tolerance and cannot be corrected by a rigging change, the fuel control is faulty -or- Check the CIT sensor per Adjustment Test, 73-1-5.	Replace CIT sensor if faulty (refer to 73-1-5).
B. Faulty fuel control	All other possible causes eliminated.	Replace fuel control (refer to 73-1-4).

5. Low Starting Fuel Flow.

Possible Cause	Isolation Procedure	Correction
A. Fire handle pulled	Check position of handle.	Position correctly.
B. Improper fuel shut-off rigging	Check rigging to fuel control fuel shut-off shaft.	Correct rigging. (Refer to Aircraft Manual.)
C. Fuel pump inoperative	Check pump output during prestart operation. 1. If there is output, pump is good. 2. If not output, pump is bad.	Replace pump. (Refer to 73-1-1.)
D. Faulty control	Other possible causes eliminated.	Replace fuel control. (Refer to 73-1-4.)

7. Fluctuating Fuel Flow.

Possible Causes	Isolation Procedures	Correction
A. Faulty fuel flow transmitter	EGT, RPM, etc. stable	Replace transmitter or gauge.
B. Faulty fuel control	All engine parameters fluctuating	Replace fuel control.

FUEL SYSTEM - MAINTENANCE PRACTICES

1. General. The information presented under system maintenance applies to the system as a whole. As such, this section deals primarily with system piping, clamping, etc. **Maintenance information which applies to an individual component is presented as part of the maintenance information for that component.**

2. Removal/Installation. Most external lines can be removed and replaced by employing normal maintenance procedures. When replacing lines, insert new "Oll-rings and install new clamps where necessary. All hose and tube connector nuts through -12 size must be lockwired. The cases which reqUire special methods will be given here.

NOTE: **If an accessory is removed and is then placed in reserve stock, it must be preserved per the instructions in 89-1-7.**

A. Pressurizing and Drain Valve to Fuel Manifold Lines. (See figure 201.)

NOTE: One-piece fuel manifold and P & D lines cannot be disassembled.

CAUTION: THE TUBES CONNECTING THE FUEL MANIFOLDS TO THE FUEL NOZZLES MAY BE BROKEN AND LEAK IF THE FOLLOWING METHODS ARE NOT OBSERVED.

(1) Removal. If either of these lines is to be removed, disconnect the manifold from the nearby fuel nozzles before starting the removal. When disconnecting the line from the fitting on the manifold, use a wrench to hold the fitting and prevent stressing the manifold.

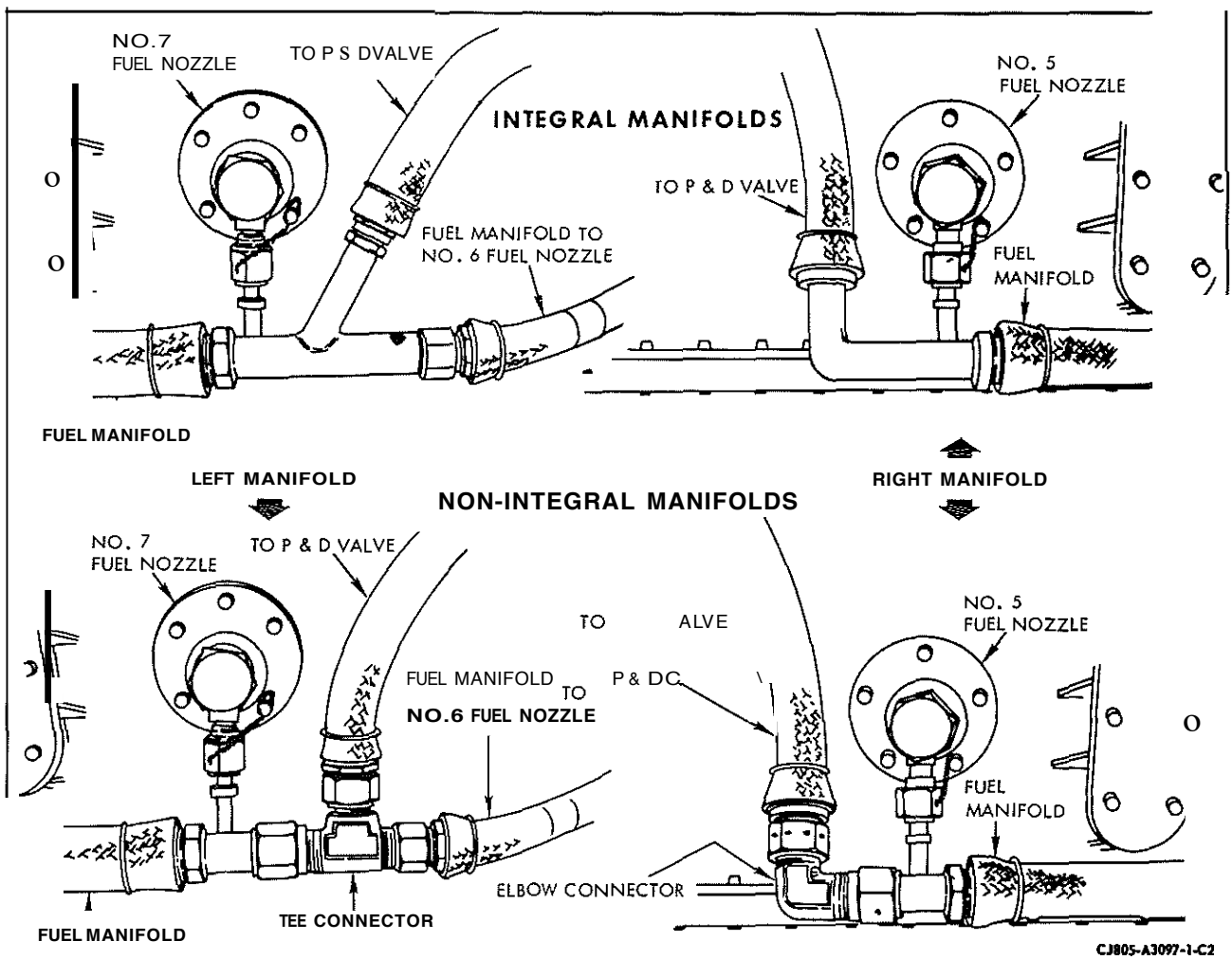
(2) Installation. When installing either of these lines, the fuel manifold must be disconnected from the nearby fuel nozzles while tightening these lines onto the manifold. After the lines are connected between the P & D valve and the manifold, connect the manifold to the fuel nozzles.

3. Adjustment/Test. The only adjustment made on the system is on the fuel control; therefore, all adjustments are in 73-1-4. System testing procedures are given below.

A. Testing of engine power reduction system.

(1) To pressure check the engine power reduction system proceed as follows:

(a) Remove the union from the compressor rear frame and cap the line.



Pressurizing and Drain Valve to Fuel Manifold Connections
Figure 201

(b) Disconnect the CDP line at the tie connection where the CDP line **goes forward to the main fuel control.**

CAUTION: BE SURE THAT LINE TC THE MAIN FUEL CONTROL IS DISCONNECTED.

(c) Pressure check the power'reduction system at 250 psig for 5 min**utes minimum. No leaks allowed. Use clean dry filtered air.**

NOTE: Tube connection points should get special attention.

4. Inspection/Check. Inspect the following items during periodic inspections of the engine.

   A. Secureness of all studs, bolts, stand-off brackets or braces to which **accessories are fastened.**

   B. Accessories for leakage and/or cracking of mounting pads.

   C. Lines and connections for leaks and/or evidence of wear.

   D. Clamping of lines for secureness.

   E. Throttle and fuel shutoff linkage for binding or excessive resistance. (Move throttle and fuel shutoff levers through full range.)

5. Approved Repairs.

   A. Tighten or replace fittings as necessary to stop leaks.

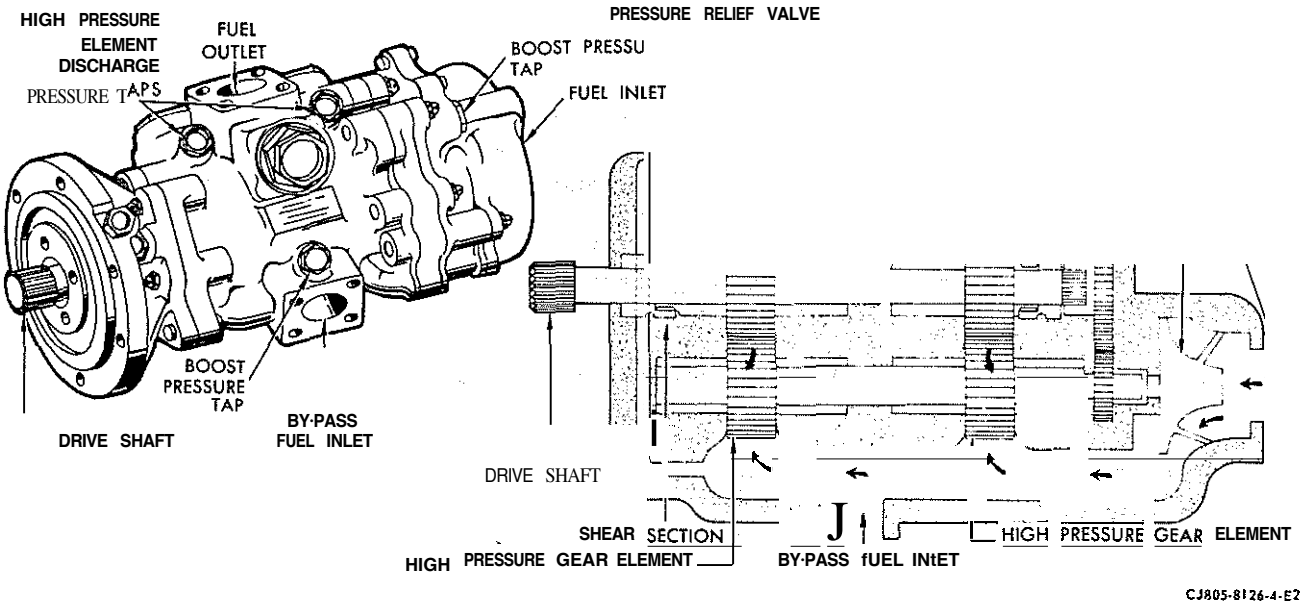
   B. Tighten bolts, brackets and fasteners which secure accessories to the engine.

   C. Remove and replace accessories with cracks in mounting pads.

   D. Remove and replace leaking and/or chafed lines. If asbestos covering **(fire-sleeve) is worn, remove the line from the engine, loosen the clamp** on each end of the line, and remove the covering. Check the line and if **no damage is eVident, install neW covering and tighten clamps. Install the line on the engine, torque connector nut and lockwire.**

   E. If leaks result from cross threading or other damage to accessories, replace the accessory. Refer to maintenance instructions on the component to which the damage occurred.

FUEL PUMP - DESCRIPrION AND OPERATION



Fuel Pump
Figure 1

1. **General. All fuel required for combustion and fuel and control system operating pressures is supplied by the engine fuel pump. General information on** the fuel pump is listed in Table 1 of Fuel Pump Data.

Table 1 - Fuel Pump Data

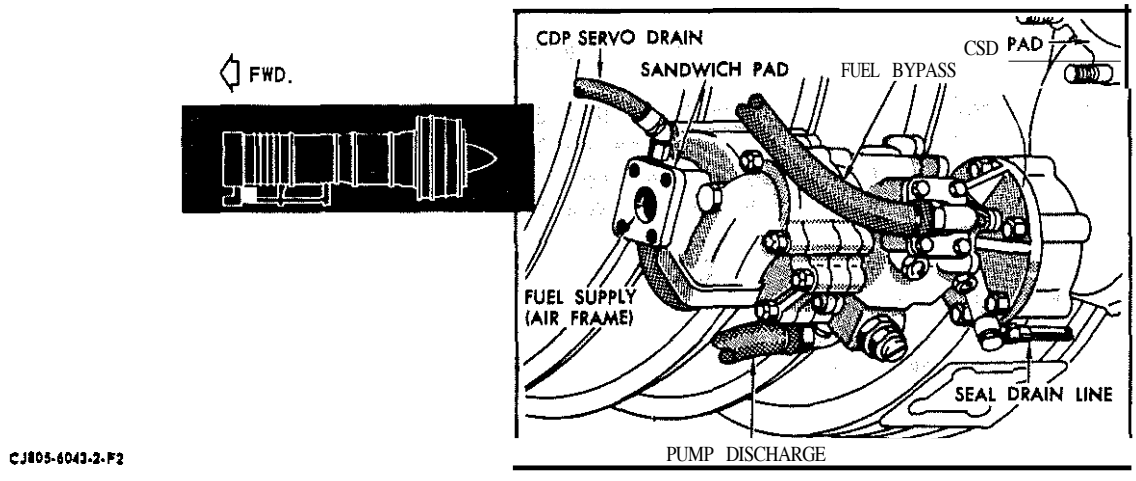
Rotation	**Counterclockwise when viewed from the drive end.**
Rated Speed	3960 rpm at 100 percent (7460 rpm) **engine speed**
LUbrication	**None required**
Leakage through Drive-Shaft Seal	**No air or oil leakage into the pump** Fuel leakage of 1 cc/minute from drain
Inlet Pressure Limit	15-50 psig
Maximum Safe Case Pressure	1,000 psi

2. Operation. Figure 1 illustrates the pump drive shaft, external ports and the internal mechanism. Supply fuel from the aircraft enters at the end opposite the drive shaft, and fuel at discharge pressure exits to the fuel heater through a port at the side. Fuel bypassed from the control enters at the by-pass port, also located at the side of the pump.

The fuel pump contains 3 pumping elements. The first is a centrifugal-type boost element which increases pump inlet pressure 15 to 45 psi. The pressure rise across the boost element varies with engine speed. Elements 2 and 3 are high-pressure, positive-displacement, gear-type elements. Each high-pressure element discharges through a separate check valve to a common outlet port. With an inlet pressure of 15 psia and discharge pressure of 850 psig, the high-pressure elements deliver 51 gallons per minute (gpm).

The pump incorporates a number of safety devices to ensure reliable operation. If either high-pressure element fails the check valve on the inactive side closes and prevents reverse flow through the faulty element. A pressure relief valve in the discharge section limits maximum discharge pressure.

The valve opens at 900 psi, porting the discharge flow internally back to the inlet side of the high pressure elements, and remains open until discharge pressure has dropped to 875 psi. If discharge pressure rises to 960 psi, the total flow is bypassed. The drive system' of each element has a shear section. The high pressure elements fail at torque values between 2500 and 3000 pound-inches, and the boost element fails between 700- and 1000-pound inches. When any element fails the remaining elements continue to operate, and the pump will supply enough fuel for moderate aircraft speed with one high-pressure element inactive.



Removal/Installation of Fuel Pump
Figure 201

1. General. Maintenance on the fuel pump is limited to removal/installation.

2. Removal/Installation. (See figure 201.)

A. Removal

(1) Check airframe fuel shutoff valve. It must be closed.

NOTE: Have container ready to catch spilled fuel when disconnecting lines.

(2) Remove fuel supply line at pump inlet.

NOTE: Do not disconnect the CDP servo drain line from the sandwich pad.

(3) Remove pump discharge line at the pump discharge port.

(4) Remove fuel bypass line at the bypass inlet to pump.

(5) Remove airframe seal drain line.

(6) Remove airframe instrumentation from pump pressure taps.

(7) Remove 6 nuts which secure pump to gearbox pad.

(8) Remove the pump by moving pump aft far enough to clear the studs. Pump can then be tilted slightly outward from the engine to clear the transfer gearbox scavenge pump discharge line.

B. Installation·

(1) Place new gasket on gearbox mounting pad.

(2) Install O-ring in the groove on the pump drive shaft.

(3) Apply a coat of Plastilube Moly No.3 (Warren Refining Co., Cleveland, Ohio 44102), Molylube 103 Grease (Bel-Ray Co., Inc., P.O. Box 526, Farmingdale, N.J. 07727) or General Purpose Moly No.3 (Southwest Grease and Oil Co., Wichita, Kansas 67201) or equivalent to the pump spline.

(4) Position the pump on the gearbox pad.

NOTE: The seal drain port should be at 8 o'clock.

(5) Install nuts on mounting studs, and torque.

(6) Connect all lines as listed:

(a) Airframe seal drain line

(b) Fuel bypass line

(c) Pump discharge line

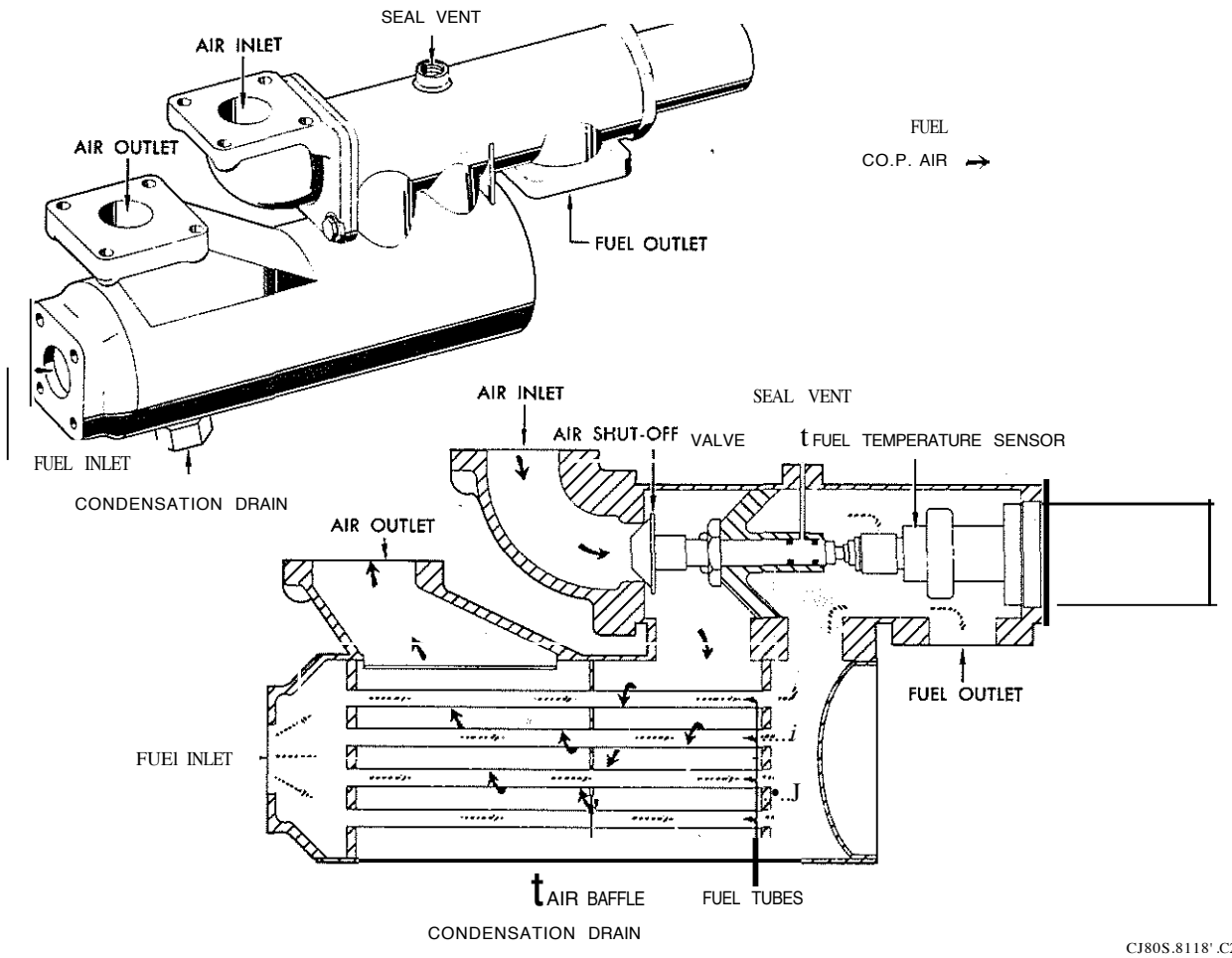
(d) Fuel aupply line, including CDP servo drain line adapter pad

NOTE: Check the CDP servo drain line on the sandwich pad to be sure that it is tight.

(7) Assemble airframe pressure pickups to pressure taps.

(8) Prime the system by air-motoring the engine. Check for leaks.

FUEL HEATER - DESCRIPTION AND OPERATION



Fuel Heater
Figure 1

1. General. The fuel heater uses 17th-stage compressor discharge air to heat fuel that flows from the engine fuel pump. The fuel heater maintains fuel temperature above freezing to protect fuel and control system components from icing. General information on the fuel heater is listed in Table 1 - Fuel Heater Data.

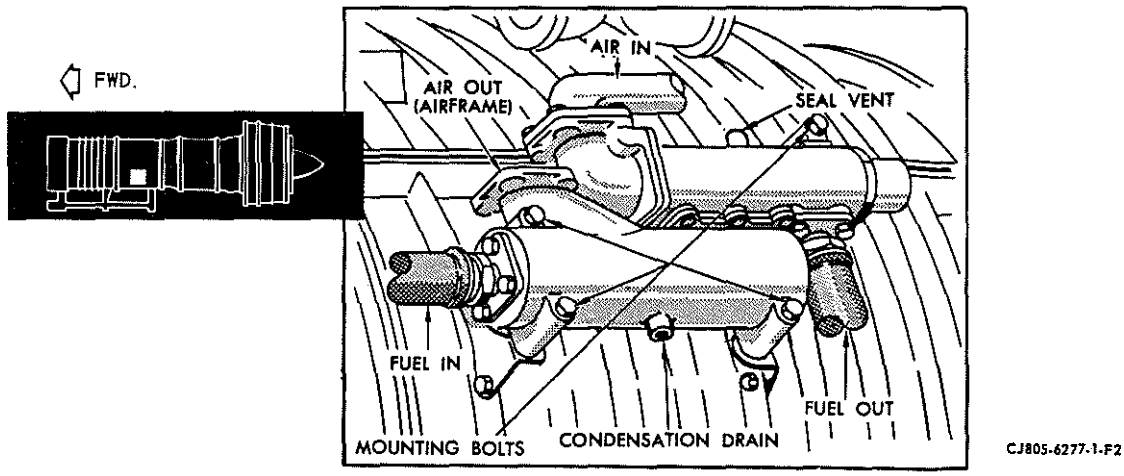
Table 1 - Fuel Heater Data

Maximum fuel pressure drop across the heater	**20 psi under any condition**
Air shutoff.....	Full Open below 33°F (0.5°C) Closed above 45°F (7°C)
Air leakage •..••••...•.•...•.•..•.;.•	Not to exceed 0.25 lb per minute at a differential pressure of 300 psi at 800°F across the shutoff valve.
Heat transfer •.•..••••.•.•....•••.•••	531 BTU when airflow is 0.55 lb per second, air temperature is 145°F (63°C) fuel flow is 225 lb per min. at an inlet temperature of 28.3°F (_2°e)
Overboard drains •.....	**1 cc min maximum - seal vent 0.033 gpm of water-air - condensation drain**

2. Operation. The fuel heater contains 2 flow circuits, one for fuel and one for air, Four ports provide an inlet and an outlet for each circuit. Fuel enters from the engine fuel pump, flows through fuel tUbes into a cavity containing the temperature sensor, and is discharged through a port at the rear end of the heater (figure 1). Fuel flows to the next system component, the fuel filter. Air to heat the fuel is tapped from the airframe bleed air manifold over the compressor rear frame. **Air enters the fuel heater, flows past the shutoff valve to the heater core, and surrounds the tubes containing cold** fuel. Air discharged from the fuel heater is vented overboard through airframe supplied piping.

A fuel-temperature sensor is located in the fuel circuit. A shaft connects the sensor to the air shutoff valve. Expansion and contraction of the sensor, resulting from changes in fuel temperature, opens or closes the valve. Two drain ports are provided on the heater-body. One is for venting the interseal area on the air shutoff valve shaft, and the other drains any water accumulation in the body. Both drains are piped to the overboard drain manifold.

FUEL HEATER - MAINTENANCE PRACTICES



Removal/Installation of Fuel Heater
Figure 201

1. General. Maintenance of the fuel heater is limited to removal/installation.

2. Removal/Installation. -(See figure 201.)

A. Removal

NOTE: A container is needed for draining fuel.

(1) Remove bolts connecting hose flanges to heater. Hoses are listed below:

(a) Air inlet.
(b) Air outlet (airframe).
(c) Fuel inlet.
(d) Fuel outlet.
(e) Seal vent (airframe).
(f) Condensation drain (airframe).

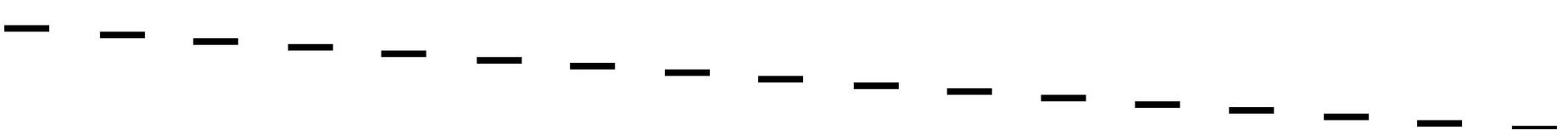
(2) Remove 4 bolts holding heater to mounting brackets, and remove the heater.

B. Installation

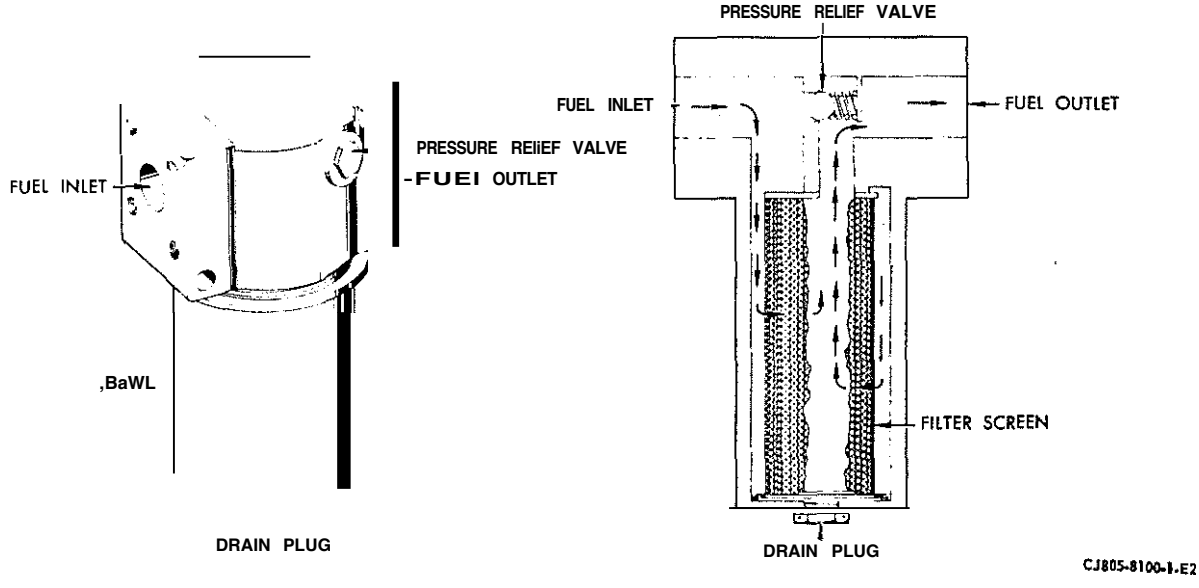
(1) Position a new unit on the bracket, and install bolts through the heater mounting bosses. Torque bolts.

(2) Connect all hose flanges. Install new O-rings and gaskets where **required.**

(3) Perform engine prestart run to prime fuel system. Check for leaks prior to engine start.



FUEL FILTER - DESCRIPTION AND OPERATION



Fuel Filter Illustration and Schematic
Figure 1

1. General. (See figure 1) All fuel discharged from the engine pump is directed through the fuel filter before reaching other components (excluding the fuel heater) in the fuel and control system. General information on the fuel filter is listed in Table 1 - Fuel Filter Data.

Table 1 - Fuel Filter Data

Pressure Relief Valve Opens At	20-24 psi differential pressure
Pressure Relief Valve Full Open At ..,	28-32 psi differential pressure
Filter Element	Sinter bonded stainless steel wirecloth
Minimum Size of Filtered Particles , ..	**40 microns**

2. Operation. A single fuel circuit, a filter element and a pressure relief valve comprise the major parts of the fuel filter. Flow from the fuel heater enters and surrounds the filter screen. Fuel passes through the screen and up to the discharge port while contaminating particles in the fuel are trapped on the face of the screen. Filtered fuel flows to the fuel control inlet port.

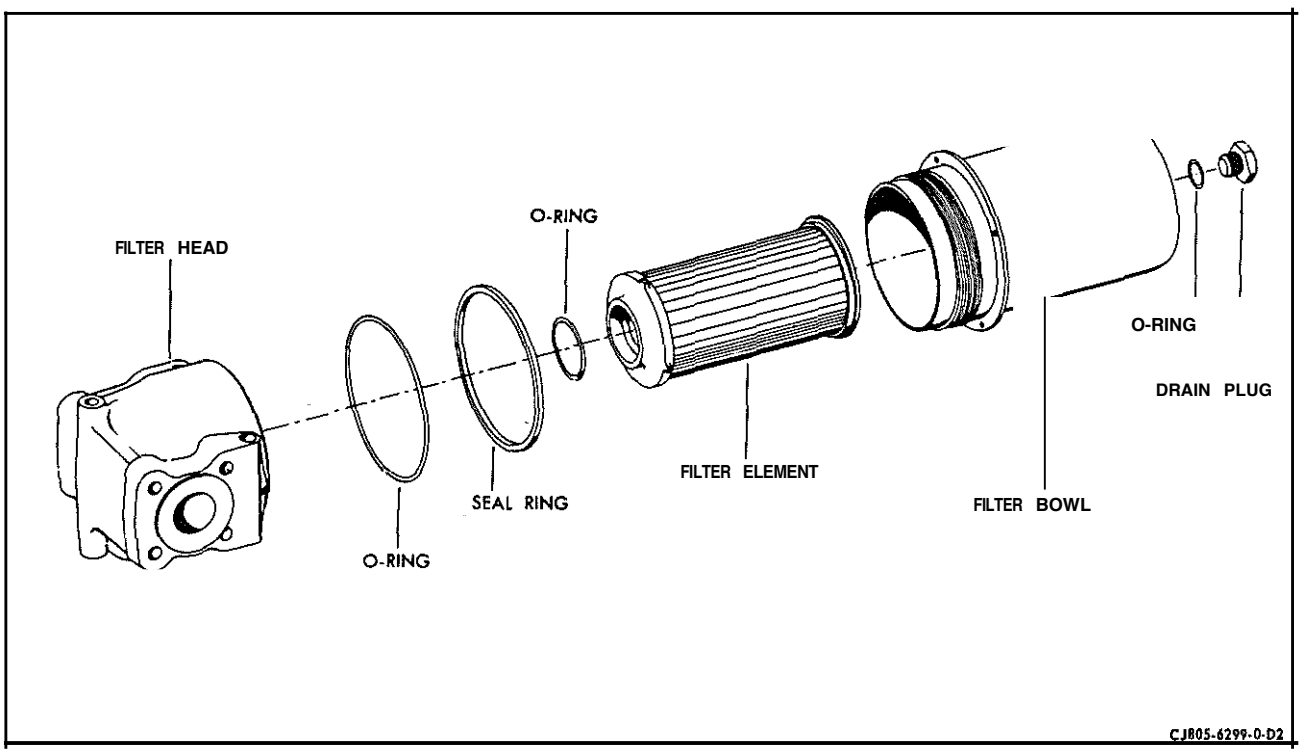
If the filter becomes clogged, due to excessive contamination, the pressure differential across the filter is increased. A bypass section in the filter contains a pressure relief valve which opens when the difference in pressure across the valve is high enough to indicate a clogged filter element. With flow through the pressure relief valve contaminated fuel is delivered to the fuel control. Therefore, it is important to periodically inspect and clean the filter.

A drain plug is provided to drain static fuel before removing the filter screen for cleaning. The filter screen is a permanent element constructed of sinter-bonded, stainless-steel wire cloth.

FUEL FILTER - MAINTENANCE PRACTICES

1. General. Fuel filter maintenance is quite limited; however, it is important to perform the servicing procedures periodically.

2. Servicing. Clean the fuel filter per the following procedure. (See figure 201.)



Exploded View of Fuel Filter
Figure 201

A. Disassemble filter as follows:

(1) Remove the drain plug and drain the fuel into a container. Assemble new a-ring and replace the plug after draining.

(2) Cut the lockwire on the filter bowl.

(3) Remove the filter bowl by turning in a counterclockwise direction. If necessary. use a wrench on the flats on the bottom of the bowl.

(4) Remove the filter element.

(5) Remove the a-ring from inside neck of filter element.

(6) Remove the a-ring and plastic seal ring from filter head.

B. Clean the filter as follows:

(1) Check the element for metal particles. If any are found, troubleshoot the upstream components of the system to locate the source of contamination, and correct the condition.

(2) Plug center hole of filter element with a cork or suitable stopper.

(3) Wash or soak the element in carbon tetrachloride or trichlorethylene. Shake off excess fluid, and blow off with low pressure filtered air.

(4) Wash the inside of the head and bowl with a clean cloth soaked in carbon-tetrachloride or trichlorethylene. Shake off excess fluid, blow off with air•

(5) Check the element for broken places. If any are found, replace the element.

C. Assemble the filter as follows:

(1) Remove plug from filter element.

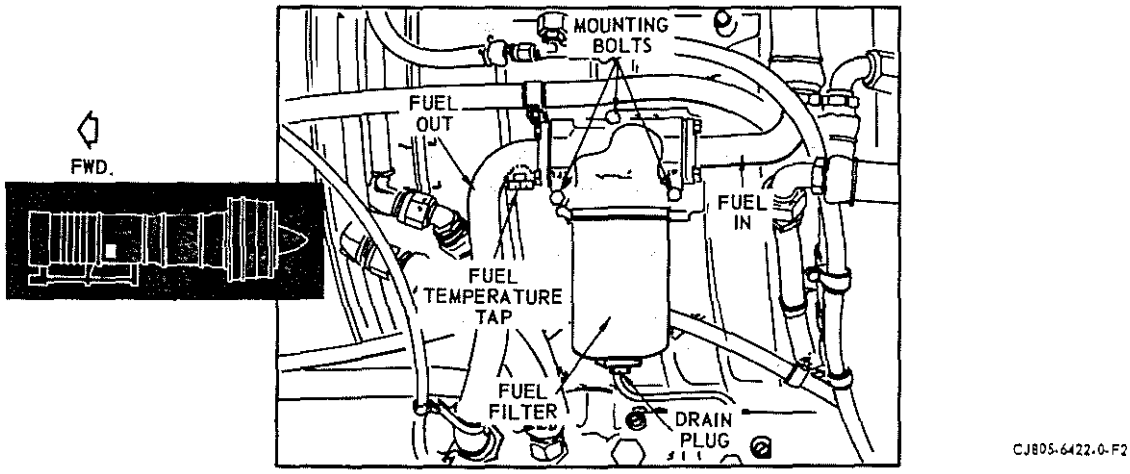
(2) Dip new a-ring in light oil and insert in neck of filter element. Install the filter element in bowl.

(3) Install new a-ring and plastic seal ring in slot in filter head. Assemble the filter bowl to the head. Tighten the bowl to 15 to 30 lb-ft., using a wrench on the flats on the bottom of the bowl.

(4) Lockwire the drain plug,

(5) Lockwire the filter bowl to the head.

D. Perform a purge run to prime the system. Check for leaks prior to starting engine.



Removal/Installation of Fuel Filter
Figure 202

3. Removal/Installation. (See figure 202.)

A. Removal

(1) Remove the drain plug and drain the fuel into a container. Assemble new a-ring and replace the plug after draining.

(2) Cut the lockwire and remove the bolts which fasten the inlet and outlet hoses to the filter.

(3) Remove the bolts which hold the filter to the mounting bracket.

B. Installation.

(1) Position the filter on the bracket.

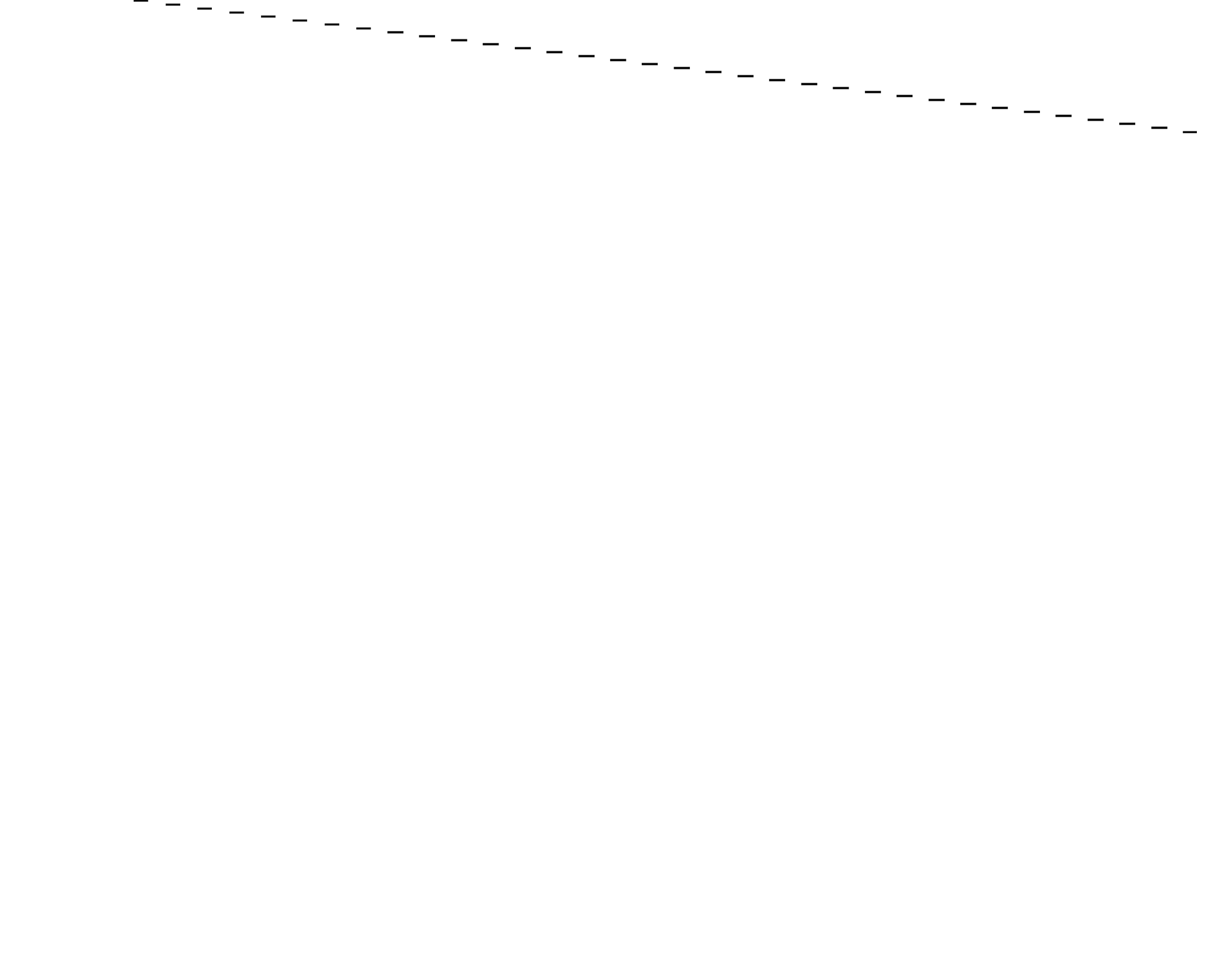
(2) Install bolts, but leave them loose.

(3) Connect the inlet and outlet hoses.

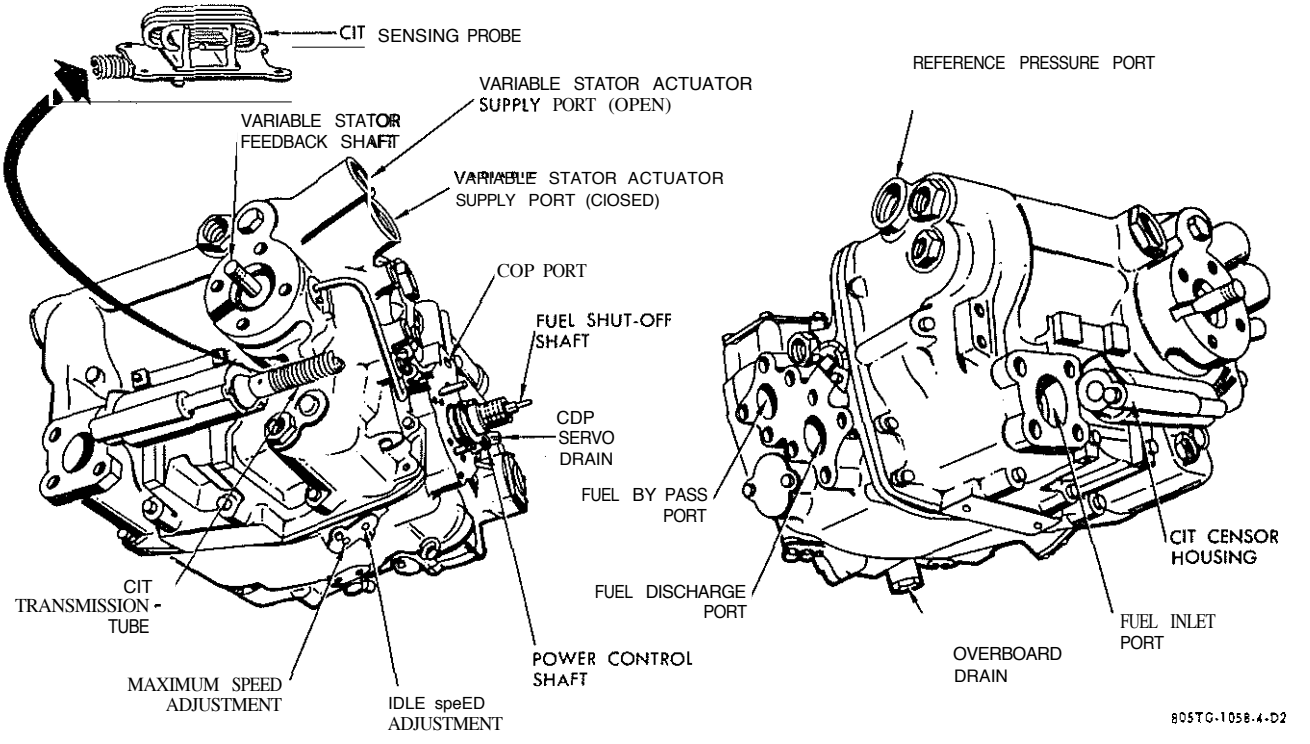
(4) Tighten and torque the bolts which secure the filter to the bracket.

(5) Torque the inlet and outlet connection adapter bolts.

(6) Perform prestart run to prime the system. Check for leaks prior to starting engine.



FUEL CONTROL - DESCRIPTION AND OPERATION



Fuel Control
Figure 1

1. General. (See figure 1.) The fuel control is a hydro-mechanical device. It performs its function by use of fuel-operated servo valves. The control performs the following functions:

   A. Controls engine speed by metering fuel to the combustion liners during acceleration, deceleration, and steady-state operation.

   B. Schedules variable stator vane position and directs high-pressure fuel to the stator actuators to position the stators as the schedule changes.

   C. Alters the fuel schedule (within safe limits) automatically to maintain the pilot's speed setting.

   D. Establishes the maximum safe fuel limit under any operating condition.

   E. Provides positive fuel shutoff operation independent of throttle position.

F. Develops and regulates its own operating pressures.

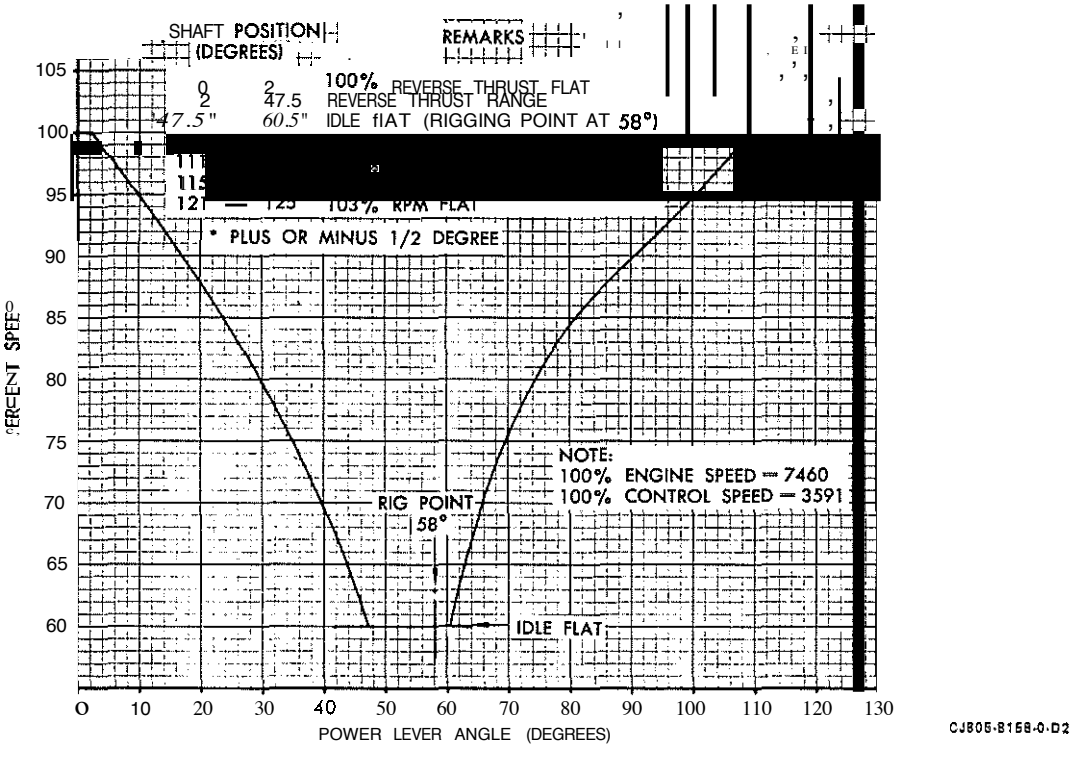
General information on the fuel control is listed in Table 1 - Fuel Control Data.

Table 1 - Fuel Control Data

Throttle Shaft Rotation	Clockwise to increase forward thrust, **counterclockwise to increase reverse** thrust (when viewed from shaft end).
Throttle Shaft Torque	15 pound-inches max (forward thrust direction)• 20 pound-inches max (reverse thrust direction).
Throttle Shaft Range (figure 2.)	
Fuel Shutoff Shaft Rotation	Clockwise to open the valve (when viewed from the shaft end).
Fuel Shutoff Shaft Torque	Varies between 0 and 15 pound-inches.
Fuel Shutoff Shaft Range	
0-10 degrees	Shutoff valve closed.
10-12 degrees	Shutoff valve opens.
10-35 degrees	Transition from full closed to full open.
35-60 degrees	Fuel shutoff valve full open.
Drive Shaft Rotation	Counterclockwise (when viewed from the drive end).
Drive Shaft Speed	3592 rpm at 100 percent engine speed (7460 rpm)
Drive Shaft Torque Limit	Shear section fails at a torque load of 300 lb-in. minimum and 1000 lb-in. max-**imum.**
Variable Stator Feedback Shaft **Rotation**	**Counterclockwise as the stators open** (when viewed from the shaft end).
Case Drain Overboard Leakage	**3 cubic centimeters per minute**

Table 1 - Fuel Control Data (Cont.)

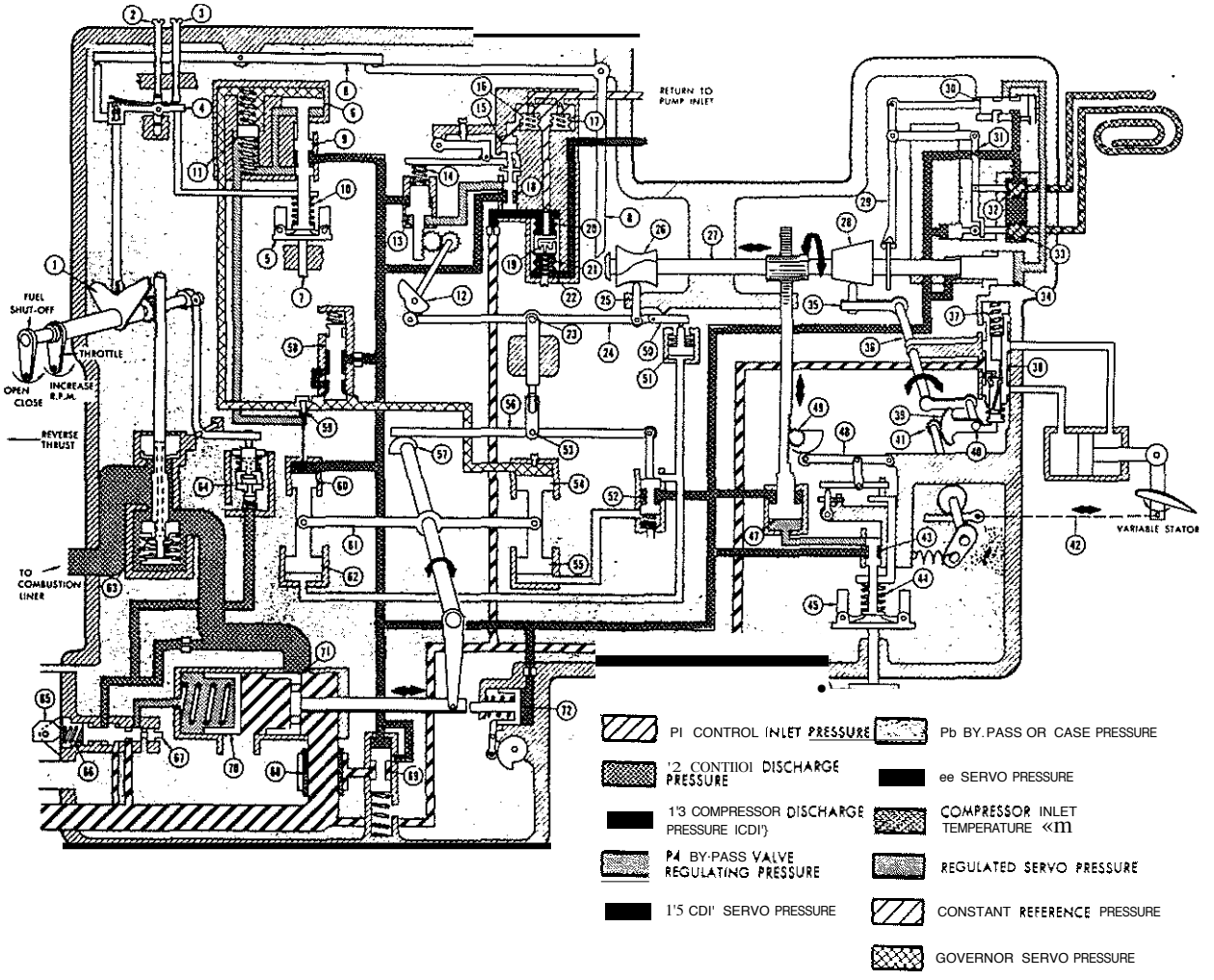
Shutoff Valve Leakage	With shutoff lever OFF, leakage should not exceed 300 cubic centimeters per minute in either direction.
Filtration •....•...••...•.•.•.••.••.••	Servo screen filter, 150 mesh. Maximum size of filtered particles 105 microns. Self cleaning.



Power Control Shaft Schedule
Figure 2

2. Operation. Figure 3 and the following description provide a limited explanation of the manner in which the functions are performed.

The CIT bellows receives an engine inlet temperature signal from a sensing probe, located on the engine front frame. The output signal from the CIT servo moves the maximum fuel limit - and variable-stator scheduling cams axially as CIT changes. The actual engine speed signal, originating from an engine driven tachometer, rotates the same 2 scheduling cams. Positions of the 2 cam followers form 2 corrected engine speed signals. The one signal



1. THROTTLE CAM
2. MAXIMUM SPEED ADJUSTMENT
3. IDLE SPEED ADJUSTMENT
4. SPEED SCHEDULING LEVER
5. SPEED GOVERNOR
6. GOVERNOR PILOT VALVE COMPENSATING LAND
7. SPEED INPUT-SEE ITEM 46
8. CIT RESET LEVERS
9. GOVERNOR PILOT VALVE
10. GOVERNOR REFERENCE SPRING
11. BUFFER PISTON
12. COP CAM
13. COP SERVO PISTON
14. COP FEEDBACK SPRING
15. COP REFERENCE PISTON
16. COP SERVO DRAIN BELLOWS
17. STAND.BY COP SERVO DRAIN eeucws
18. COP PILOT VALVE
19. AIR SUPPLY DIAPHRAGM
20. COP IIEILOWS
21. STAND-BY CDI' IIELLOWS
22. COP ADJUSTING SPRING
23. PIVOT POINT, ADDING LEVER
24. ADDING LEVEII
25. FUel IIMIT CAM FOLLOWER
26. MAXIMUM FUEL LIMIT CAM
27. CAM CARRIAGE
28. VARIABLE STATOR SCHEDULING CAM
29. CIT FEEDBACK LEVER
30. CIT PiIOT VALVE
31. CIT SENSOI TRANSMITTING IEVER
32. OI COMPENSATING eeuows
33. CIT BEILOWS
34. CIT SERVO PISTON
35. VARIABLE STATOR CAM FOIIOWER
36. CAM FOLLOWER LEVER
37. VARIABLE STATOR PILOT VALVE SPRING
38. VARIABLE STATOR PILOT VALVE
39. VARIABLE STATOR FEEOIIACK GEAR
-C. VARIABLE STATOR FEEDBACK LEVER
41. VARIABLE STATOR FEEDBACK GEAR
42. VARIABLE STATOR fEEDBACK LINKAGE
43. TACHOMETER PILOT VALVE
44. TACHOMETER REFERENCE SPRING
45. TACHOMETER FIYWEIGHTS
46. SpEED INPUT _ FIOM GEARBOX
47. TACHOMETER SERVO PISTON
48. TACHOMETER FEEDBACK LEVER
49. TACHOMETER FEEDBACK GEAR
50. DE-CAMMING LEVER
51. DE-CAMMING PISTON
52. FUEL LIMIT PILOT VALVE
53. PIVOT POINT OF FUEL LIMIT COMPARISON LEVER
54. GOVERNOR SERVO PISTON
55. ACCELERATION LIMIT PISTON
56. FUEL LIMIT COMPARISON LEVER
57. FUEL CAM
58. UNDERSHOOT LIMITING VALVE
59. VARIABLE ORIFICE
60. GOVERNOR REFERENCE PISTON
61. GOVERNOR SERVO IEVER
62. DECELERATION LIMIT PISTON
63. FUEL SHUT.OFF VALVE
64. PUMP UNLOADING VALVE
65. SPECIFIC GRAVITY ADJUSTMENT
66. PRESSURE REGULATING VALVE SPRING
67. PRESSURE REGULATING VALVE
68. SERVO FILTER
69. SERVO PRESSURE REGULATING VALVE
70. BY-PASS VALVE
71. METERING VALVE
72. MINIMUM FLOW PISTON

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. Fuel Control Schematic
Figure 3

from the variable stator scheduling cam controls the operation of the variable stator servo. The other signal from the maximum fuel limit cam is used in the fuel schedule computing circuit.

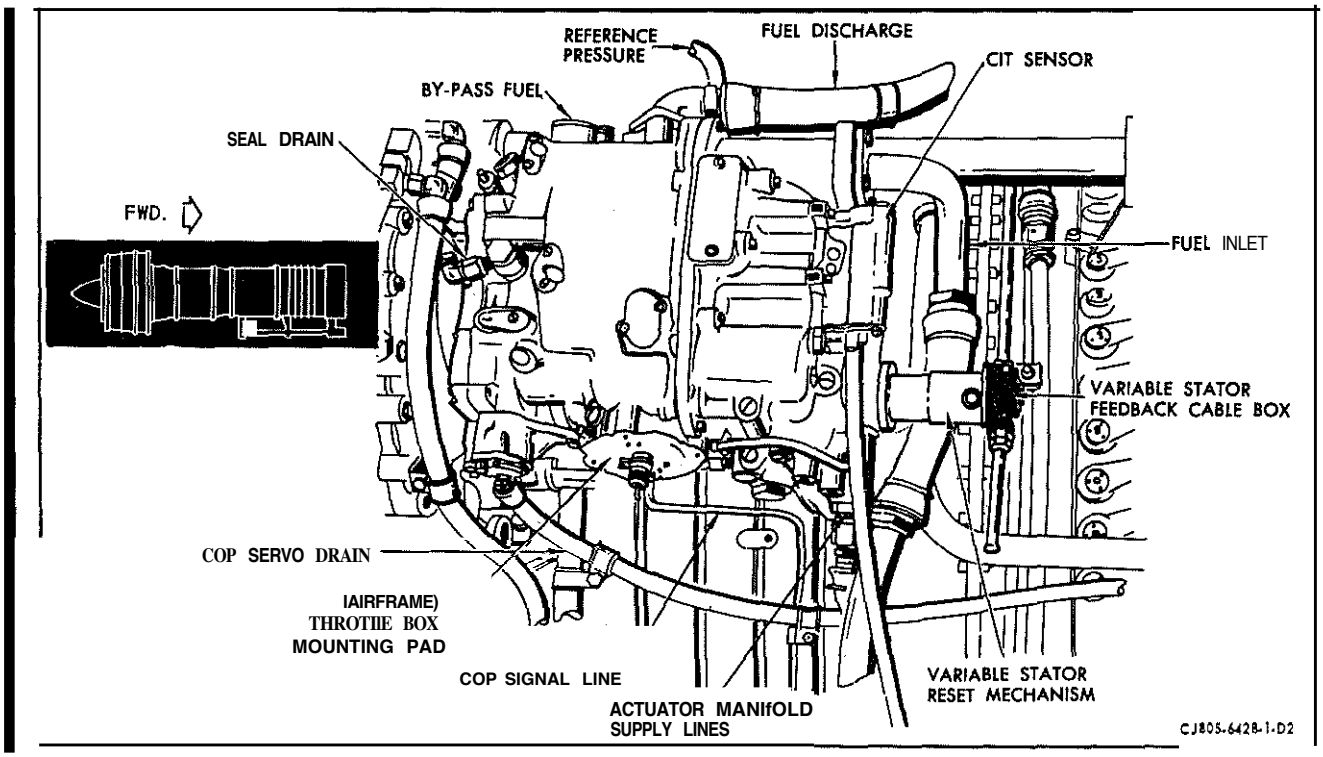
The corrected engine speed signal, mentioned above, is supplied to the variable stator servo and represents desired stator angle. A variable stator feedback signal, developed at the No. 1 actuator bellcrank and transmitted to the fuel control by flexible cable, represents actual stator position. The variable stator servo valve is positioned by the 2 signals and directs high-pressure fuel to the rod- or head-ends of both variable stator actuators.

The second corrected engine speed signal is used to compute the maximum fuel schedule. Compressor discharge pressure, tapped from a port in the compressor rear frame and amplified through servo valves, is also used in computing the maximum fuel limit. The throttle signal, controlled by the pilot, is applied to the speed sensing governor. The speed governor monitors actual engine speed through engine driven flyweights. If actual and desired speeds differ, the speed governor attempts to correct the off-speed conditions by discharging an off-speed signal to the governor servo piston.

The governor servo receives the hydraulic signals resulting from throttle angle, CDP, CIT and actual engine speed. By integration of these signals the governor servo determines the position of the metering valve. Fuel is metered by varying the area of the metering valve orifice while maintaining a constant differential pressure across the valve. A pressure regulating valve regUlates the metering valve differential pressure by varying the amount of excess fuel returned to the pump. (Refer to fuel sUb-system description for further details.) The minimum fuel flow for starting is guaranteed by the minimum flow piston.

The fuel shutoff valve is located in the discharge section of the fuel control. Throttle linkage to the fuel shutoff shaft originates the signal that controls position of the shutoff valve.

Regulated servo pressure used by hydraulic circuits in the fuel control is maintained at a constant value above case pressure by the servo pressure regulating valve.



Removal/Installation of Fuel Control
Figure 201

1. General. Maintenance of the fuel control consists of removal/installation and adjustment/test.

2. Removal/Installation. (See figure 201.)

   A. Removal

      (1) Remove the CIT sensor from the control.

      NOTE: Do not remove sensor probe from the front frame. Secure the sensor housing to the engine so that the capillary tubes will not be broken. Do not bend the capillary tubes to a radius of less than 2½ inches.

      (2) Disconnect and tag the hoses listed below.

         (a) Fuel inlet

         (b) Actuator manifold supply lines - 2 connections

(c) Fuel **discharge**

(d) Fuel bypass

(e) **Reference pressure**

(f) **Seal drain**

(g) CDP **servo drain**

(h) CDP inlet

(3) Remove the engine torque box. Refer to Chapter 7G, Aircraft Maintenance Manual.

(4) Disconnect the variable stator feedback from the control as follows:

(a) Remove the variable stator feedback rod-end bearing from the stud on the variable stator bellcrank. (See figure 201 and 202, section 73-1-9.) Release the spring tension in the control by allowing the spring to pUll the cable into the cable box.

CAUTION: DO Nor ALLOW CABLE TO SNAP BACK.

(b) Remove the shaft nut on the cable box. Remove the mounting bolts **which secure the box to the variable stator reset mechanism.**

(c) Move the cable box and the attached conduit forward enough to **give room for removing the variable stator reset mechanism.**

(d) Remove the bolts that secure the variable stator reset mechanism **and remove from the control.**

(5) Loosen the V-band clamp which secures the control to the gearbox **mounting pad, move the control forward to clear the drive shaft and remove control from the engine.**

CAUTION: THE FUEL CONTROL WEIGHS APPROXIMATELY 50 POUNDS, THIS WEIGHT MUST BE SUPPORTED WHEN THE V-BAND CLAMP IS LOOSENED, UNDER NO CONDITION SHOULD THE WEIGHT OF THE CONTROL BE PERMITTED TO REST ON THE DRIVE SHAFT. THE SHAFT CAN BE FRACTURED BY WEIGHT ON THE CONTROL.

(G) If the control is removed from the engine and then placed in spare parts stock, it must be preserved by performing the following:

(a) Drain all fluid.

(b) Plug all openings except CIT sensor opening.

(c) Place protective covers over linkage shafts.

(d) Pour oil, MIL-O-GOS1, through CIT sensor opening. Fill control to top of CIT sensor opening.

(e) Install shipping block on CIT sensor opening.

(f) Lay control on side and turn it slowly through one complete turn to coat all internal parts with oil.

(g) Rotate the drive shaft one or more turns.

(h) Install wooden shipping block on drive shaft.

(i) Store in upright position,

B. Installation.

(1) Remove all fittings from the control, which were removed from the engine, and assemble these fittings on the new control.

(2) Place a new gasket on the gearbox mounting pad. Coat the drive spline of the control with Plastilube Moly No.3 (Warren Refining Co., Cleveland, Ohio 44102), Molylube 503 Grease, (Bel-Ray Co., Inc., P.O. Box 526, Farmingdale, N.J. 00727) or General Purpose Moly No.3 (Southwest Grease and Oil Co., Wichita, Kansas 67201) or equivalent.

(3) Place the control on the engine. Rotate the control as necessary to align the drive shaft spline with the spline in the gearbox. Secure the control to the gearbox with the V-band clamp. Torque the clamp to 65 pound-inches.

CAUTION: DO NOT PERMIT THE WEIGHT OF THE CONTROL TO REST ON THE DRIVE SHAFT OF THE CONTROL. MAKE CERTAIN THE CONTROL IS SUPPORTED UNTIL THE V-BAND CLAMP IS IN PLACE AND TIGHTENED. THE SHAFT CAN BE FRACTURED BY WEIGHT OF THE CONTROL.

(4) Connect the following hoses to the control, and lockwire. Fuel inlet, variable stator fuel manifold -2 lines, fuel discharge, fuel bypass, reference pressure, seal drain, CDP servo drain and CDP inlet.

(5) Place the variable stator reset mechanism on the control feedback shaft and secure in place with bolts. Torque and lockwire.

(6) Assemble variable stator feedback cable box to the variable stator reset mechanism. Rig the feedback cable. (Refer to step "3.C", Adjustment and Test, in this section.)

(7) Place the CIT sensor on control housing. Use new gasket. Dowel pin on control housing determines the position of the sensor. Secure the sensor with the mounting screws.

NOTE: Be sure the CIT transmitting lever in the control seats properly. If installed properly, the CIT sensor will seat without requiring force.

(8) Install the engine torque box on the control, and rig. Refer to Chapter 76, Aircraft Maintenance Manual.

(9) Air-motor the engine purge the system and check for leaks.

(10) Adjust variable stator feedback cable to obtain proper running rig in accordance with 72-0, Adjustment/Test, Procedure 3.C.

3. Adjustment/Test.

CAUTION: DO NOT ATTEMPT ADJUSTMENTS OTHER THAN THOSE CALLED OUT HERE. THE CONTROL CAN BE DAMAGED IF UNAUTHORIZED ADJUSTMENTS ARE ATTEMPTED.

A. Idle Speed Adjustment. (See figure 202.) Normal idle speed is 4475 rpm. The adjustment range is from 4250 to 4700 rpm. Each click of the adjustment screw results in a speed change of 26 rpm. Turn adjustment screW clockwise to increase speed. Use 0.125-inch Allen wrench. Make adjustment with engine running at idle. (Refer to 72-0, Adjustment/Test, paragraph 5.)

NOTE: Make certain the airframe rigging is correct.

B. Maximum Speed Adjustment. (See figure 202.) Normal maximum speed is 7684 rpm. The adjustment range is from 7833 to 7311 rpm. Each click of the adjustment screw results in a speed change of 9.333 rpm. Turn adjustment screw clockwise to increase speed. Use 0.1875-inch Allen wrench. To make the adjustment, refer to 72-0, Adjustment/Test, paragraph 5.

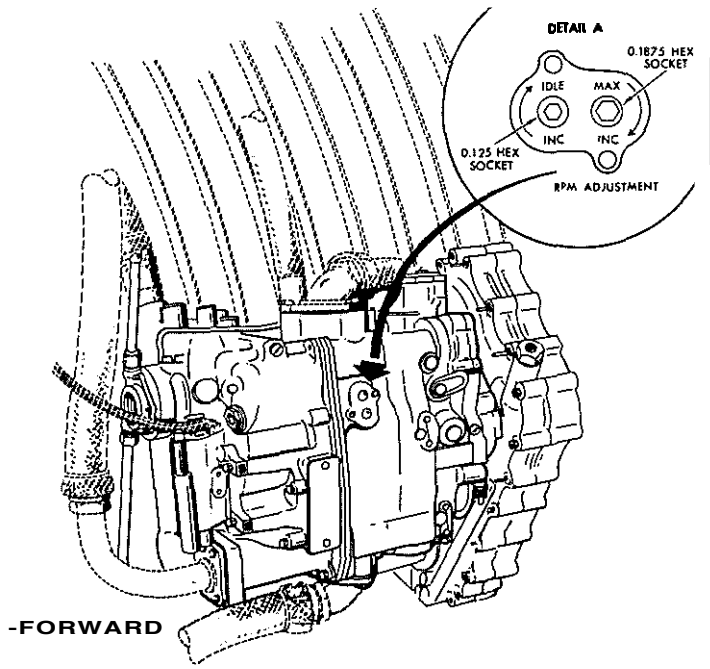
C. Variable Stator Feedback Rigging Procedure for the Sheave-Wheel Type Feedback System. Proper rigging of the variable stator feedback is necessary in order to maintain a properly functioning system. If the control is replaced or the feedback system disturbed, use the following rigging procedure for the sheave-wheel type feedback system. (See paragraph 3.D. for the rack and pinion feedback system rigging procedure.)

(1) Disconnect the variable vane feedback cable from the first-stage bellcrank. (Refer to 73-1-9.)

CAUTION: THE VARIABLE STATOR FEEDBACK LINKAGE IS SPRING LOADED IN THE FUEL CONTROL. DO NOT ALLOW THE CABLE TO SNAP BACK, RELIEVING THE SPRING TENSION RAPIDLY.

(2) Connect the hydraulic pump, 2C4005, (or equivalent) to the actuator manifold by removing the actuator lines from the fuel control and connecting the cart to the lines.

NOTE: Place cap on the fuel control openings.



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Adjustment ~ Fuel Control
Figure 202

(3) Install a variable vane position indicator, 2C4436, on the third **vane below the left horizontal flange of the second stage of vanes, looking forward from rear of engine.**

NOTE: The 2C4436 indicator is a mechanical protractor that must be **read while mounted on the engine.**

(a) Screw the protractor drive (center) adapter on the third vane shaft and tighten it with a 1/2 inch open end wrench.

(b) Screw the locator pin adapter onto the second vane shaft and tighten it with a 1/2 inch open end wrench.

(c) Slide the protractor over the drive adapter pin. Make certain **that the tabs on the protractor are in the slot in the lever arm and the protractor locator slot fits over the locator pin.**

(d) Tighten the locator slot screw on the locator pin.

(4) Open the variable stators to the full open position so the actuators hit the stops. Then slowly close the stators until the protractor **reads 24 degrees ± 15 minutes.**

(5) Place an Allen wrench in the feedback shaft of the fuel control. Loosen the shaft locknut. Push the shaft in to disengage the sheave. Allow the shaft spring tension to unwind slowly.

NOTE: If the tabwasher on the shaft nut has been previously bent, it must be replaced.

(6) Remove the access plug from the feedback rigging pin port of the fuel control. Install an Allen wrench in the feedback shaft. With the sheave disengaged, rotate the shaft approximately 3/4 turn in a counterclockwise direction until the rigging pin, 2C4338, can be slipped into place.

(7) With the sheave disengaged, by holding the control shaft in, connect the feedback cable to the first-stage bellcrank feedback bracket.

NOTE: Make sure that at least 2 threads of the cable extend past the adjustment nut at the rod-end bearing.

(8) Hold the shaft in the rigging pin position with the Allen wrench, and remove the rigging pin. Tighten the shaft nut. Rotate the shaft slightly, while tightening, to ensure proper engagement of the shaft and sheave teeth. Torque the shaft nut to 30-40 pound-inches.

CAUTION: DO NOT TORQUE THE SHAFT NUT WITH RIGGING PIN INSTALLED.

(9) Holding the cable (to prevent the spring in the fuel control from unwinding rapidly) slide the rod-end bearing off the first-stage bellcrank stud.

(10) Allow the spring tension to pull the cable into the cable box. Pull out the cable, and let it return several times to check for freedom of movement. The cable should retract smoothly.

(11) Reassemble the rod-end bearing on the first-stage bellcrank bracket.

(12) Insert rigging pin into the fuel control. If the pin cannot be inserted easily, adjust the jam nut and adjustment nut at the rod-end bearing until the pin can be inserted and removed easily. Torque the jam and adjustment nuts to 24-36 pound-inches.

NOTE: When adjusting the cable length, hole the cable. If the cable is allowed to rotate, it will affect the rigging.

(13) Remove the protractor and rigging pin, and install the access plug in the rigging pin hole.

(14) Using the hydraulic cart, cycle the stators open and closed several times. Check to see that the rig position has stayed the same. If it has moved, adjust the system.

(15) Disconnect the hydraulic cart, and connect the actuator manifold lines to the fuel control.

NOTE: After static rigging of the control, the engine should be run and the feedback cable adjusted to obtain proper running rig of the variable stators. (Refer to 72-0, Adjustment/Test, paragraph 3.)

D. Variable Stator Feedback Rigging Procedure for the Rack and Pinion Feedback System. (See paragraph 3.C. for the sheave-wheel type feedback system.)

(1) Perform steps C.(1) through C.(4).

(2) Loosen the circular nut on the variable reset mechanism (VSRM) shaft and disengage the teeth of the mating serrated surfaces.

(3) Remove the plug from the rig pin access port on the fuel control and insert rigging pin into wheel. Rotate the VSRM shaft with a 1/8-inch Allen-wrench CCW to engage rigging pin.

CAUTION: DO NOT ALLOW THE FEEDBACK SHAFT TC UNWIND RAPIDLY. DUE TO SPRING TENSION, INTERNAL DAMAGE MAY RESULT.

(4) Install the rod-end bearing on the bellcrank stud. Check for free travel of the feedback cable.

(5) Pullout the VSRM shaft to engage the serrations in the control box and torque the circular shaft nut on VSRM shaft using a 1/4-inch Allen-wrench.

NOTE: Insert liS-inch Allen-wrench in VSRM shaft and apply side load to pUll shaft out to engage serrations. Tighten circular nut finger-tight before removing Allen-wrench from shaft.

(6) Turn rod-end bearing onto or off of cable assembly until the rig pin slips in and out of the slot freely.

NOTE: If cable assembly is turned in or out of rod-end bearing, instead of adjusting length by turning rod-end bearing on or **off of cable assembly be sure an open end or adjustable wrench** of proper size is used to turn cable at flats.

(7) Remove the rigging pin and disengage the rod-end bearing from the stud. Allow the cable to be pulled back into VSRM by spring tension. **Check several times for smooth operation.**

(8) Replace rod-end bearing to stud and insert rigging pin. Adjust, if necessary by turning rod-end bearing. Install nut and washers (thin washer goes between bearing and nut). Torque and lockwire nut on stud and the nut locking the cable assembly to the rod-end bearing. Insert cotter .pin through hole in threaded end of cable assembly and bend ends of cotter pin.

(9) Remove the protractor and rigging pin, and install the access plug in the rigging pin hole.

(10) Using the hydraulic pump, cycle the stators open and closed several times. Check to insure that the rig position has not changed. If it has moved, adjust the system.

(11) Disconnect the hydraulic cart and connect the actuator lines to the fuel control.

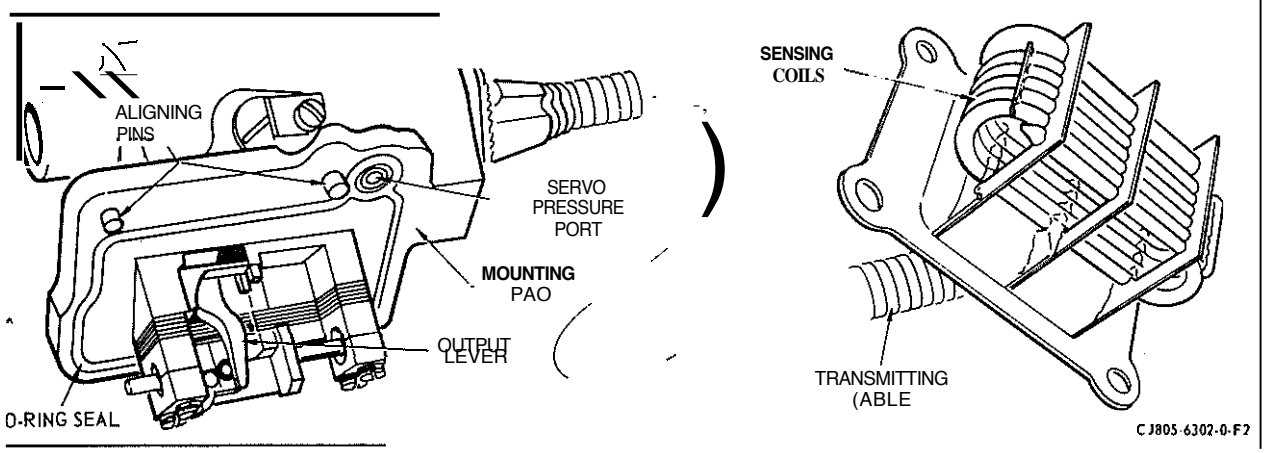
NOTE: After static rigging of the control, the engine should be run and the feedback cable adjusted to obtain proper running rig of the variable stators. (Refer to 72-0, Adjustment/Test, paragraph 3.)

4. Approved Repair. No repairs to the fuel control may be affected in the field. Replace faulty control.

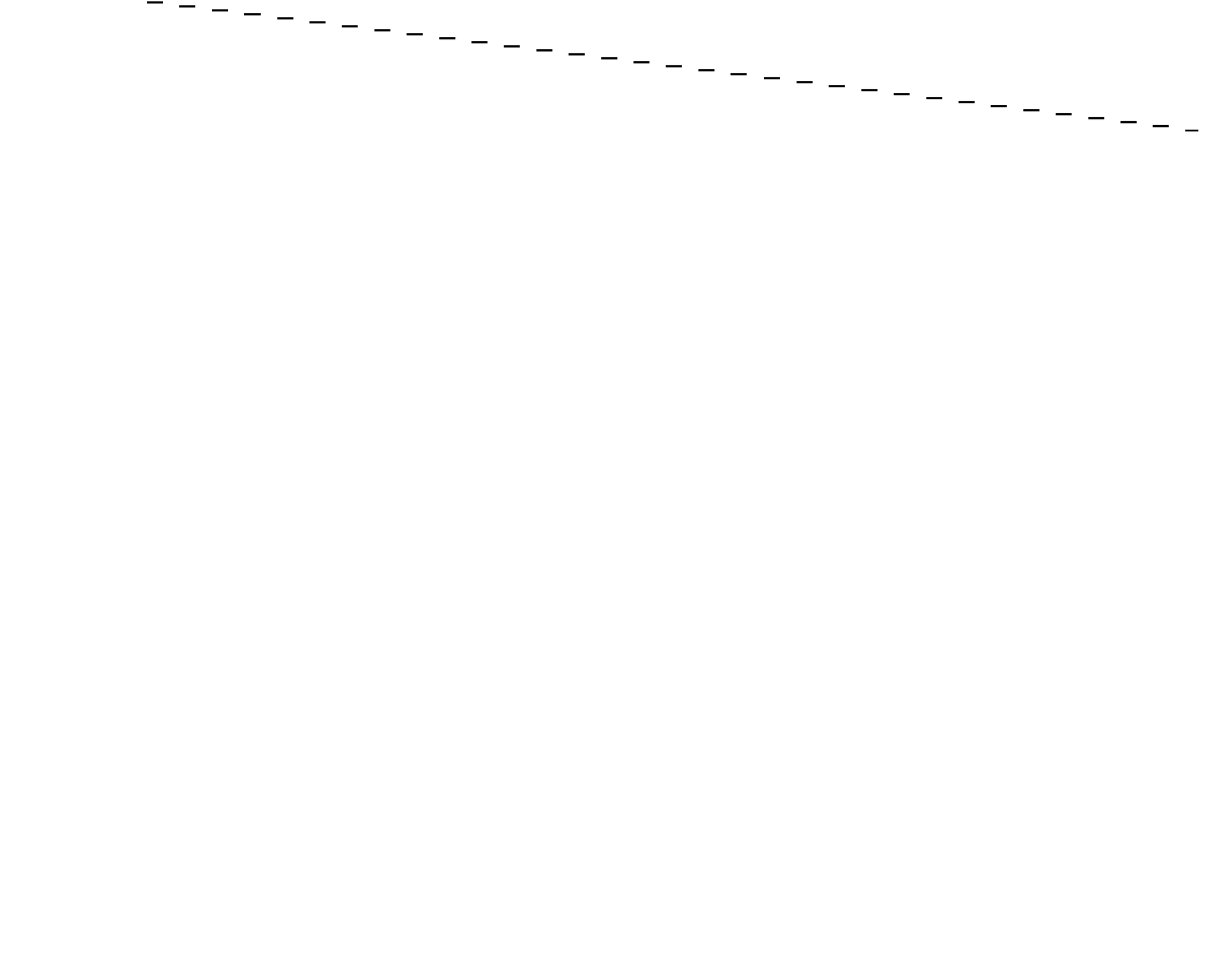
COMPRESSOR INLET TEMPERATURE SENSOR - DESCRIPTION AND OPERATION

1. General. (See figure 1.) The compressor inlet temperature sensor supplies a **signal, representing the temperature of the air entering the engine, to the fuel control. The temperature sensing coil is mounted in the compressor front frame, while the transmitting unit is mounted on the fuel control.**

2. **Operation.** **The CIT sensor translates temperature change into a mechanical** signal at the fuel control. Two capillary tUbes are filled with a temperature sensitive fluid. One tube is affected by temperature changes at the **sensing coil. The other tube compensates for the effect of temperature** changes along the route of the tube, thus eliminating possible errors from **this source. Expansion or contraction of the fluid is mechanically trans-** mitted to the fuel control. A Teflon and wire braid cover is installed over the tubes to protect them from damage.

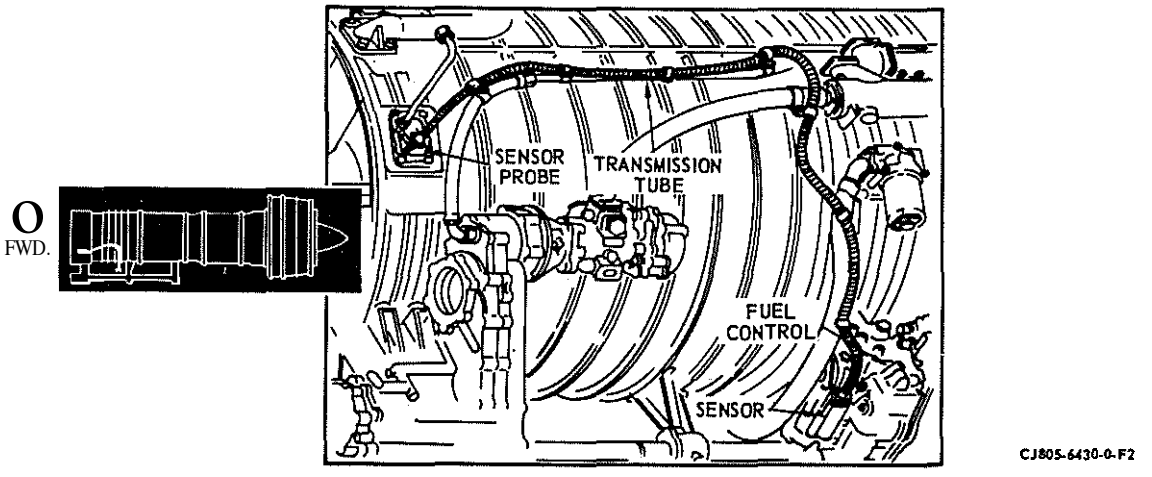


Compressor Inlet Temperature Sensor
Figure 1



COMPRESSOR INLET TEMPERATURE SENSOR - MAINTENANCE PRACTICES

1. General. The CIT sensor maintenance is limited to replacement. The following information will cover this operation.



Removal/Installation of CIT Sensor
Figure 201

2. Removal/Installation. (See figure 201.)

A. Removal

(1) Disconnect the anti-icing tUbe from the sensor.

(2) Remove the bolts that secure the sensing coils in the front frame.

(3) Remove the clamps which secure the capillary tubes.

(4) Remove the bolts holding the sensor unit on the fuel control, and remove the sensor from the engine. Remove and discard the gaskets.

CAUTION: DO NOT BEND THE CAPILLARY TUBES TO A RADIUS OF LESS THAN 2½ INCHES.

(5) If the sensor' is removed from the engine and then placed in spare parts stock, it must be preserved by performing the following procedure:

(a) Drain and/or wipe away excess fluid.

(b) Pour small amount of oil, MIL-O-60S1, Grade 1010, into output lever opening and turn sensor from side to side to coat all internal parts.

(c) Drain excess oil from sensor.

(d) Plug openings and install shipping blocks.

CAUTION: DO NOT ATTEMPT TO CLEAN ORIFICE BY ANY METHOD.

B Check air de le tor for cracks.

(1) Six radi l racks from the center ho e, 5/16 inch 10 g, are allowable.

(2) No crack are allowed outsid a 0.75 inch iameter f the shroud face o n he Low Smoke Combus or fuel nozzl (seeligure 2.)

(3) No circu erential cracks a

Check air d ector for indenta i ward). ny amount is acceptable.

Check the body of the nozzle for cracks. No cracks aL allowable.

E. Deleted.

4. Approved Repair.

A. Any amount of carbo buildup can be removed.

B. Replace any nozzle that exceeds the serviceable limits.

(e) Coil capillary tubing and tie with rawhide.

CAUTION: DO NOT BEND CAPILLARY TUBING TO A RADIUS LESS THAN 2½ INCHES.

B. Installation.

(1) Install a new gasket and position the sensor on the control housing. **Dowel pins on the control housing aid in positioning the sensor.**

NOTE: Be sure that the CIT transmitting lever in the control seats properly. If installed properly, the sensor unit will seat without force.

(2) Secure sensor unit to the control. Torque and lockwire bolts.

(3) Install a new gasket and place the sensing coil in the front frame. Secure with bolts. Torque the bolts.

(4) Install the anti-icing tube onto the sensor. Torque the connectors to 90-100 Ib-ins. and lockwire.

(5) Install clamps to secure the capillary tube.

3. Adjustment/Test. The following procedure may be used to check a CIT Sensor which is suspected as being damaged. By using a CIT Simulator on the fuel control in place of the CIT, the engine can be operated to see if the difficulty is cleared, thereby determining if the CIT sensor is functioning properly.

A. Disconnect the CIT sensor unit from the fuel control by removing bolts securing the sensor to the control and lift the unit away from the control. Remove and discard the gaskets.

CAUTION: DO NOT BEND THE CAPILLARY TUBES TO A RADIUS OF LESS THAN 2½ INCHES.

B. Install the CIT Simulator, 2C4038, onto the fuel control, using a new gasket. Secure with bolts that hold sensor unit.

C. Set the micro-dial on the simulator to the proper value to correspond to **the ambient temperature.**

NOTE: Sheet 5 of drawing 2C4038 contains the micro-dial setting vs. **temperature chart.**

D. Operate the engine and note if the operating difficulty has been eliminated. If it has the CIT sensor is faulty and must be replaced; if not, CIT sensor is good and trouble-shooting must continue.

E. After check is complete remove the simulator and install sensor unit with with new gaskets.

4. Inspection/Checks.

A. Inspect capillary tubes for leakage. Discoloration of tube is a good indication of leakage. A shift to the cold side of the variable stator schedule is also a good indicator. No leakage is permitted.

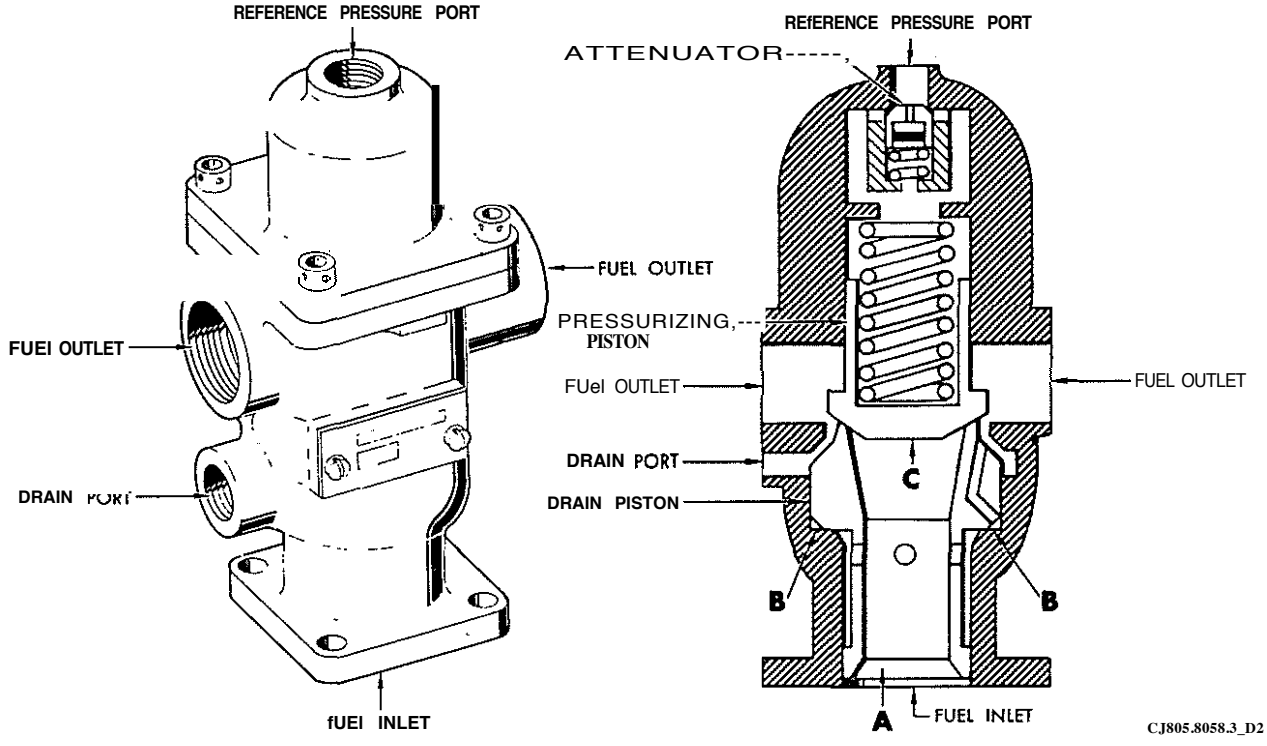
B. Inspect sensing coil for nicks or dents using a 10-power glass. No nicks or dents permitted.

C. Inspect the sensing coils for accumulation of dirt or oil. Remove dirt with soft brush. Remove oil with carbon tetrachloride and dry with shop air.

CAUTION: THIS BUILDUP OF DIRT SOMETIMES INDICATES LEAKAGE. AFTER CLEANING THE COILS, CHECK FOR NICKS, DENTS OR CRACKS THAT MAY BE THE SOURCE OF LEAKS.

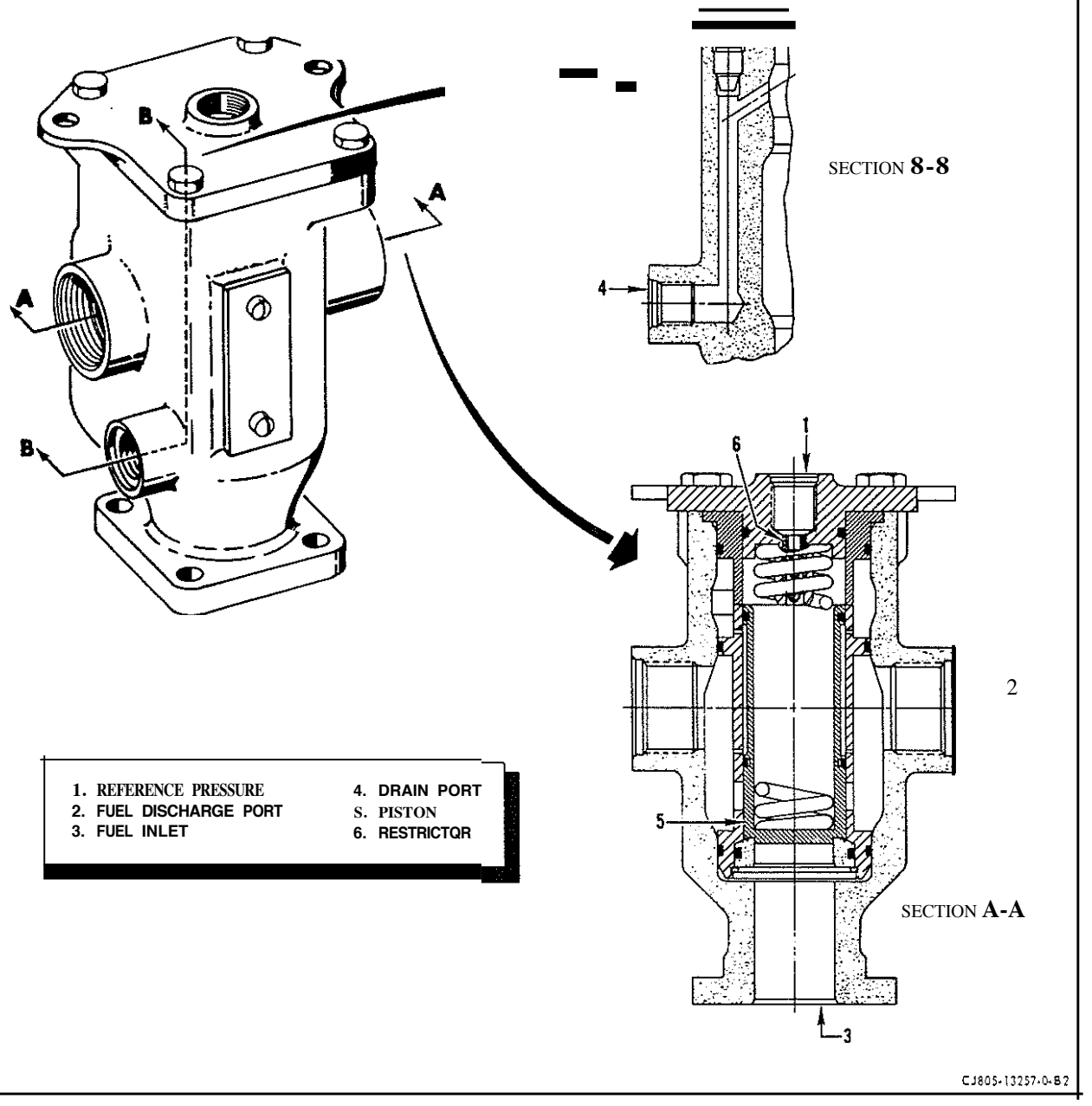
5. Approved Repair. No repairs to sensor may be made in the field. Replace faulty sensor.

PRESSURIZING AND DRAIN VALVE - DESCRIPTION



Pressurizing and Drain Valve (Type I)
Figure 1

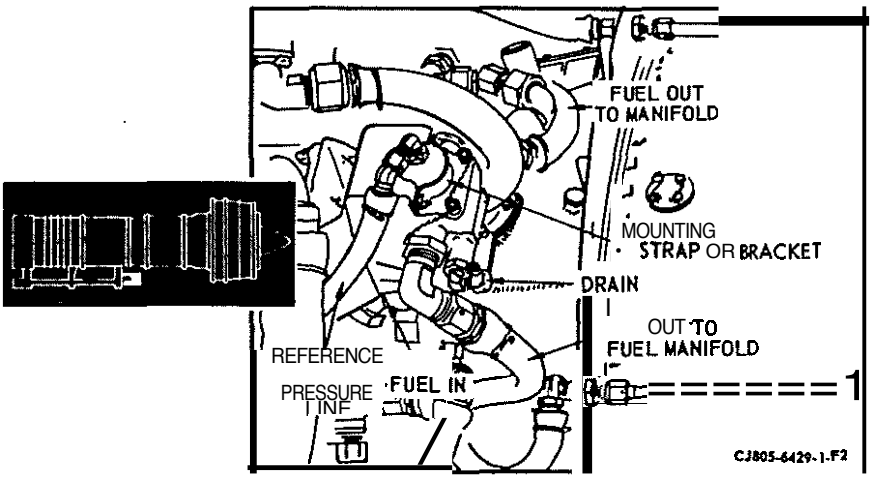
1. General. (See figure 1.) During starting of the engine the pressurizing and drain valve (P & D valve) prevents fuel flow to the engine until working **pressures in the fuel control are sufficient to operate the servo assemblies** which generate fuel and variable stator schedules. At shutdown the P & D valve drains fuel in the manifold to prevent the possibility of post-shutdown **burning or residual fuel coking in the manifold, but primes the upstream section of the fuel line to prepare the system for the next start. General information on the P & D valve is listed in Table 1 - Pressurizing and Drain** Valve Data.



Pressurizing and Drain Valve (Type II)
Figure 2

PRESSURIZING AND DRAIN VALVE - MAINTENANCE PRACTICES

1. **General. Maintenance of the pressurizing and drain valve is limited to** removal/installation.



Removal/Installation of Pressurizing and Drain Valve
Figure 201

2. Removal/Installation. (See figure 201.)

A. Removal

NOTE: Container is required for fuel spillage during removal.

(1) Remove the following hoses:

(a) Fuel inlet.

(b) Fuel outlets, one on each side of the valve.

(c) Reference pressure.

(d) Overboard drain.

(2) Loosen the 2 bolts securing the strap or bracket (depending on valve **configuration) at the reference pressure end of the valve. Remove** the valve.

NOTE: Disconnecting the fuel inlet hose freed the other end of the **valve.**

B. Installation

(1) Position the new valve in the strap or bracket (depending on valve **configuration) with the reference pressure end pointing down.**

(2) Connect the fuel inlet hose to the valve. Two of the bolts hold the valve on the bracket.

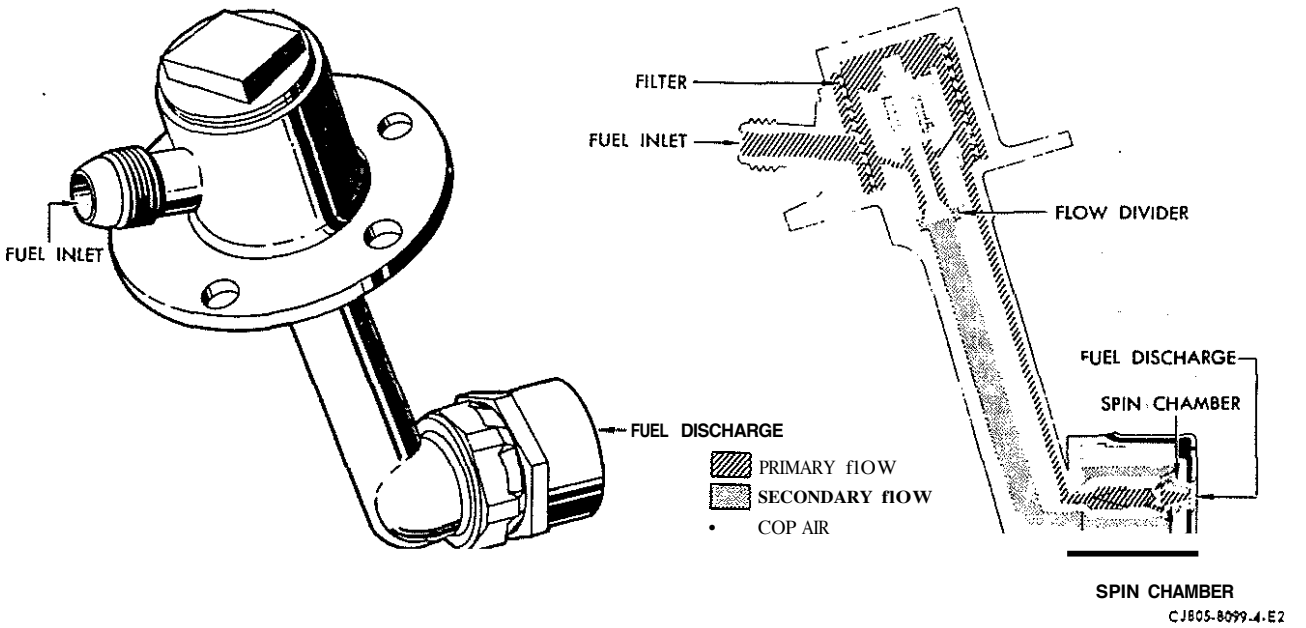
(3) Tighten bolts in the 2 straps or upper half of bracket (depending on valve configuration) until the valve is held securely.

(4) Connect the remaining hoses to their proper positions on the valve.

(5) Lockwire all bolts.

(6) Perform a prestart run to prime the system and check for leaks before starting the engine.

FUEL NOZZLES - DESCRIPTION AND OPERATION



Fuel Nozzle (Standard Combustor)
Figure 1

1. Standard Combustor Fuel Nozzle. (See figure 1.)

NOTE: For Description and Operation of the Low Smoke Combustor Fuel Nozzle, see paragraph 2.

A. Description. Metered fuel is sprayed into the combustion liners by 10 dual-cone fuel nozzles, one in each liner. General information on the fuel nozzles is listed in Table 1 - Fuel Nozzle Data.

Table 1 - Fuel Nozzle Data (Standard Combustor)

Primary Filter Screen	120 mesh
Secondary Filter Screen	100 mesh
Low Pressure Spray Angle	95-115 deg arc
High Pressure Spray Angle	85-95 deg arc
Cross-over Pressure	90 psig (approximately)

B. Operation. Each fuel nozzle has a low-pressure and a high-pressure flow path. A flow divider valve directs fuel first through one circuit, then through both circuits as inlet fuel pressure increases. At low inlet pressures, fuel enters through a port common to both flow paths, and passes through a primary filter screen. The flow divider directs fuel through a passage in the nozzle stem, a secondary filter screen and into a spin chamber. Fuel entering the chamber changes direction abruptly, and acquires a spinning motion before continuing to a discharge orifice in the spray tip. As fuel inlet pressure (fuel manifold pressure) at the nozzle inlet increases the flow divider admits fuel into a second passage in the stem. This flow path also contains a spin chamber and a discharge orifice.

Separate flow paths with separate discharge orifices arranged concentrically on the face of the spray tip (which prompts the term dual cone) encourages a favorable spray pattern throughout the wide range of metered fuel flow. The air shroud which surrounds the spray tip cools the surface around the discharge orifice, and retards the accumulation of carbon deposits that might distort the spray pattern. Air-flow from the shroud also helps confine the higher temperatures to the center of the combustion liner, away from the liner walls.

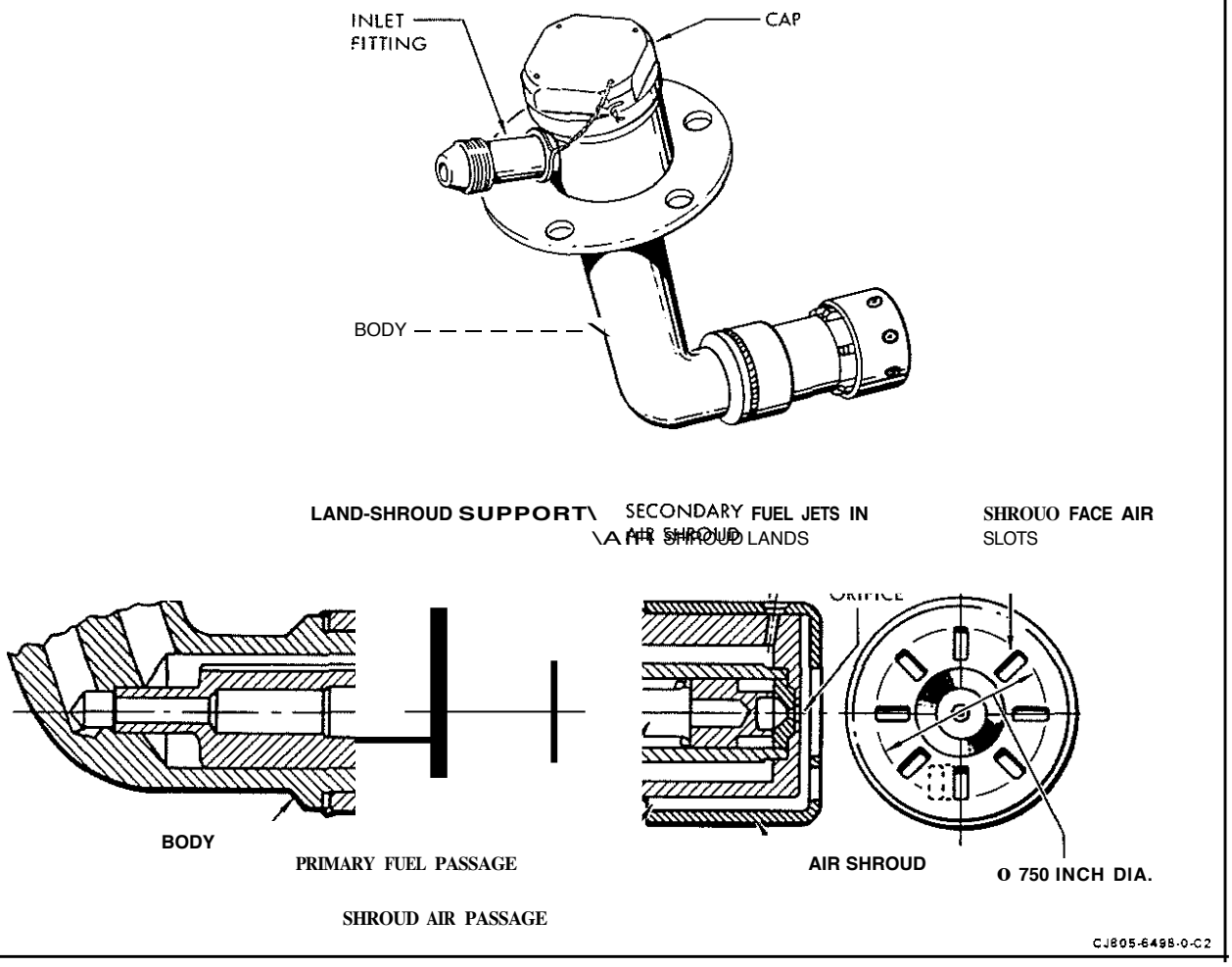
2. Low Smoke Combustor Fuel Nozzle. (See figure 2.)

NOTE: For Description and Operation of the Standard Combustor Fuel Nozzle, see paragraph 1.

A. Description. The fuel nozzle used with the low smoke combustor is similar in appearance to the nozzle used with the ,standard combustor except that the tip is about two inches longer and has a smaller diameter. The LSC nozzle sprays secondary flow radially from the outside diameter of the tip as opposed to the concentric flow with the primary orifice on the standard combustor nozzle. The face of the air shroud has 8 slots for swirling the air in place of the straight through holes as on the standard nozzle. General information on the LSC fuel nozzle is listed in Table 2.

Table 2 - Fuel Nozzle Data (Low Smoke Combustor)

Filter Screen	100 mesh
Spray Angle (Primary Flow)	38-52 deg arc
Secondary Flow Opening Pressure	80-125 psig



Fuel Nozzle (Low Smoke Combustor)
Figure 2

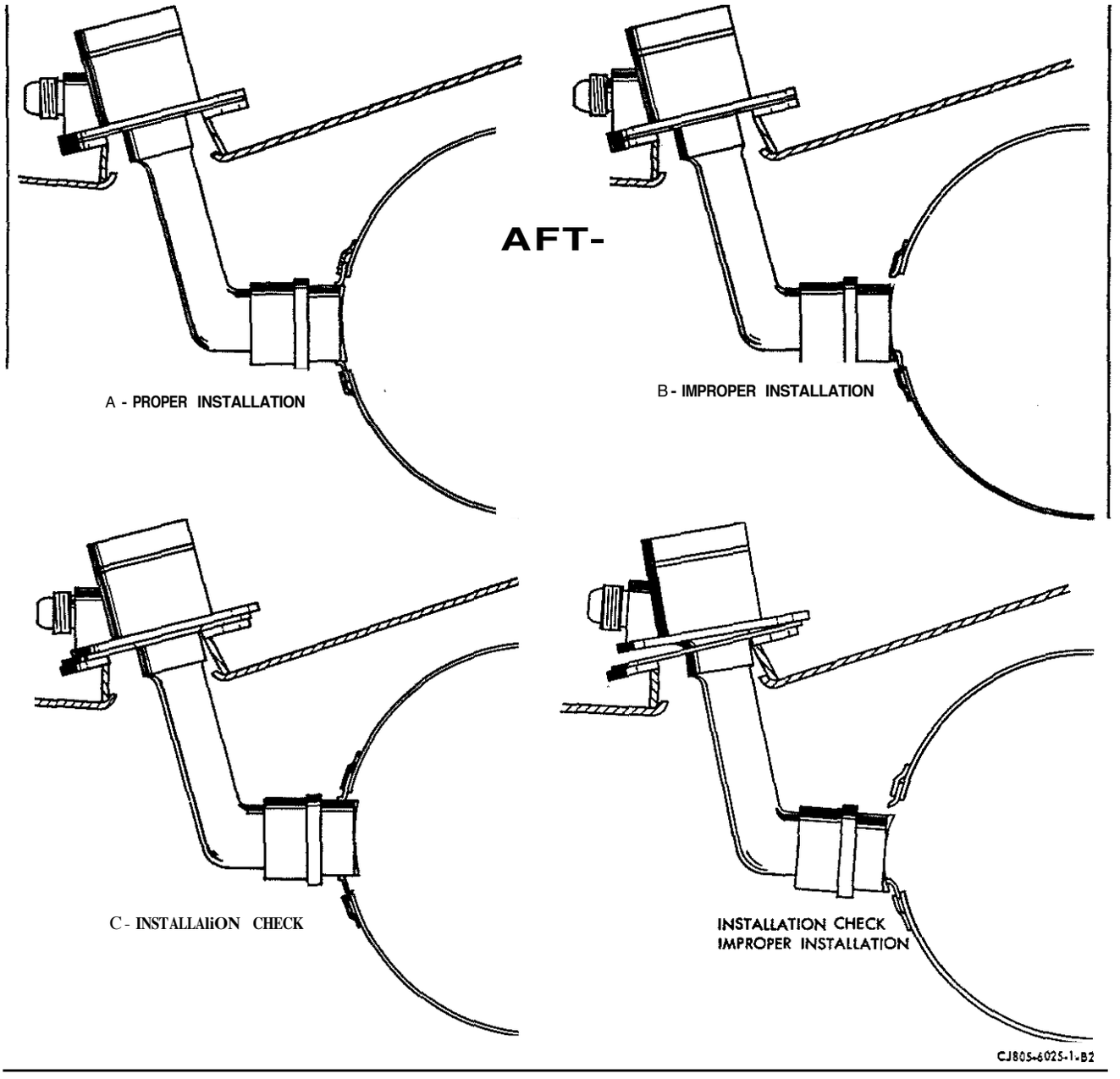
B. Operation. Each fuel nozzle has a primary and secondary flow path. The primary path is open at all times and flows approximately 25 pounds per hour. This is operating alone during starting. As fuel pressure increases to about 110 psig the secondary fuel flow starts with the opening of the flow divider in the head of the nozzle. The secondary flow is discharged through the holes on the OD of the air shroud. The fuel is discharged in a partially tangential direction to start spinning. The air through the combustor inner liner barrel is also spinning so a thorough fuel-air mixture is attained. The secondary flow increases with fuel pressure and continues to increase up to 1800 pph.

FUEL NOZZLES - MAINTENANCE PRACTICES

1. General. Fuel nozzle maintenance is limited to Removal/Installation. This information is given in the following paragraphs.

2. Removal/Installation.

A. Removal: All of the nozzles can be removed provided the area can be



Removal/Installation of Fuel Nozzles
Figure 201

cleared.

(1) Disconnect the manifold from the fuel nozzle.

(2) Remove the bolts and nuts securing the nozzle to the compressor rear frame.

(3) Remove the fuel nozzle and its gasket.

B. Installation. (See figure 201.)

CAUTION: BEFORE INSTALLING THE FUEL NOZZLE INSPECT THE COMBUSTION INNER LINER FOR LOOSE OR MISSING INNER BUSHING. THIS INSPECTION IS MADE BY LOOKING INTO THE FUEL NOZZLE PORT. IF THE BUSHING IS NOT IN PLACE, THE COMBUSTION LINER MUST BE REPLACED.

(1) Insert the fuel nOZZle, with a new gasket, into the port in the compressor rear frame. Insert the air shroud of the nozzle into the eyelet of the combustion liner (detail A, figure 201.)

(2) Check for proper alignment of nozzle with liner.

(a) With the nozzle flange flush against the mounting flange slide the nozzle to the rear.

(b) If the flanges stay flush, the nozzle is properly installed (detail C, figure 201).

(c) If the flanges tend to separate when nozzle is slide to the rear, the nozzle is not properly installed (detail D, figure 201). Remove the nozzle and repeat installation.

(d) Slide the nozzle forward until the bolt holes are aligned. Hold **nozzle in place.**

NOTE: Do not slide the nozzle forward past the bolt holes. **Nozzle will come out of the combustion liner and necessitate starting over.**

(3) Secure the nozzle in place with bolts. Torque bolts to 55-60 pound-**inches.**

NOTE: Do not allow the nozzle to slide forward, it will slip out of the liner eyelet. This requires installation to be repeated.

(4) Connect the fuel manifold to the nozzle.

3. Inspection/Checks.

A. Check air deflector for carbon buildup. Any amount of buildup is allowable. All air holes may be closed. Carbon is allowed on nozzle tip body **under** the shroud but must be external to spray orifice.

CAUTION: DO NOT ATTEMPT TO CLEAN ORIFICE BY ANY METHOD.

B. Check air deflector for cracks.

(1) Six radial cracks from the center hole, 5/16 inch long, are allowable.

(2) No cracks are allowed outside a 0.750 inch diameter of the shroud face on the Low Smoke Combustor fuel nozzle. (See figure 2.)

(3) No circumferential cracks allowable.

C. Check air deflector for indentation (warping inward). Any amount is acceptable.

D. Check the body of the nozzle for cracks. No cracks are allowable.

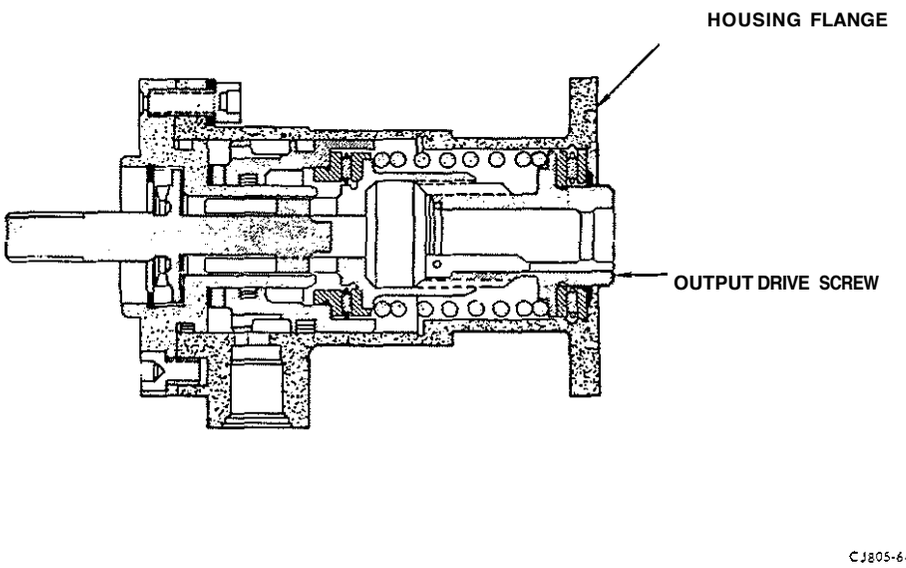
E. Deleted.

4. Approved Repair.

A. Any amount of carbon buildup can be removed.

B. Replace any nozzle that exceeds the serviceable limits.

VARIABLE STATOR RESET MECHANISM - MAINTENANCE PRACTICES



Variable Stator Reset Mechanism
Figure 201

1. Removal/Installation. In removal and installation of reset mechanism part number 1852-3, remove and install the loose washer which acts as an extension to the output drive screw. On all other assemblies the washer is either permanently bonded to the end of the drive screw or the drive screw itself is longer. On these assemblies the spring loaded drive screw or permanently bonded washer extends beyond the flange face as shown in Figure 201 and NO LOOSE WASHER IS USED.

   A. Removal.

      (1) Disconnect the variable stator mechanical feedback assembly (see 73-1-9).

      (2) Disconnect.the signal line from the variable stator reset mechanism•.

      (3) Remove the variable stator reset mechanism by removing the bolts securing it to the control.

   B. Installation.

      (1) Align the key on the IGV input shaft on the fuel control with the key

slot in the output drive of the reset mechanism, install the reset mechanism on the control and bolt in place. Torque and lockwire.

CAUTION: USE CARE TO ALIGN THE KEY SLOT IN THE VSRM AND THE KEY ON THE lOV SHAFT OF THE CONTROL BEFORE INSTALLING THE VSRM. IF THE KEY AND SLOT ARE NOT ALIGNED, THE OUTPUT DRIVE SCREW IN THE VsRM IS SPRING LOADED AND CAN BE FORCED INTO THE VSRM DURING INSTALLATION.

(2) Connect the variable stator mechanical feedback assembly (see 73-1-9).

(3) Connect the signal line, that runs between the thrust reverser pilot valve and the reset mechanism, to the reset mechanism.

2. Adjustment/Test. If it is desirable to check the variable stator reset mechanism for proper operation with the engine running, the following procedure may be used.

NOTE: If the variable stator reset mechanism does not operate properly, it must he replaced. There are no adjustments that can be made.

A. Install the variable vane position indicator 2C4019. (Refer to 73-1-4.)

B. Connect a hydraulic pump, 2C4006, to the variable stator reset mechanism signal port as follows:

(1) Disconnect the line connecting the thrust reverser pilot valve to the **variable stator reset mechanism.**

NOTE: Close-off the tee-connector port at the pilot valve by using a **pressure cap.**

(2) Connect the hydraulic pump 2C4006 to the signal line going to the variable stator reset mechanism.

C. Start the engine and advance the speed until the variable stator vanes are open 10 degrees, 0 minutes from the full closed position as measured on the 2C4019 indicator.

D. Using the hydraulic pump 2C4005 signal the variable stator reset mechanism to reset.

NOTE: Signal pressure must be between 200-2000 psig.

E. Check the vane angle reading on the indicator. The reset mechanism should close the vane 8-1/2 ± 1/4 degrees.

F. Release the pressure on the reset signal line. The vanes should open to a 10 degree reading.

G. Cycle the variable stator reset mechanism several times, checking the vane position each time.

H. Shut-down the engine and remove the hydraulic pump.

I. Remove the cap from the tee-connector at the pilot valve and connect the signal line. Torque and lockwire.

CHAPTER 74 - IGNITION

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74-0 COMPLETE IGNITION SYSTEM. (This information is located in the Aircraft Maintenance Manual.)

74-1 AIRCRAFT SUB-SYSTEM. (This information is located in the Aircraft Maintenance Manual.

74-2 ENGINE SUB-SYSTEM

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ENGINE IGNITION - DESCRIPrION

1. General. The ignition system provides the spark which ignites the fuel-air **mixture in either the No. 4 or No.5 combustion liner. The flame is distributed through crossfire ducts from the liner in which combustion occurs, igniting the fuel-air mixture in the remaining combustion liners. Once ignited, the fuel-air mixture continues to burn. Therefore, it is necessary to energize the ignition circuit only during start.**

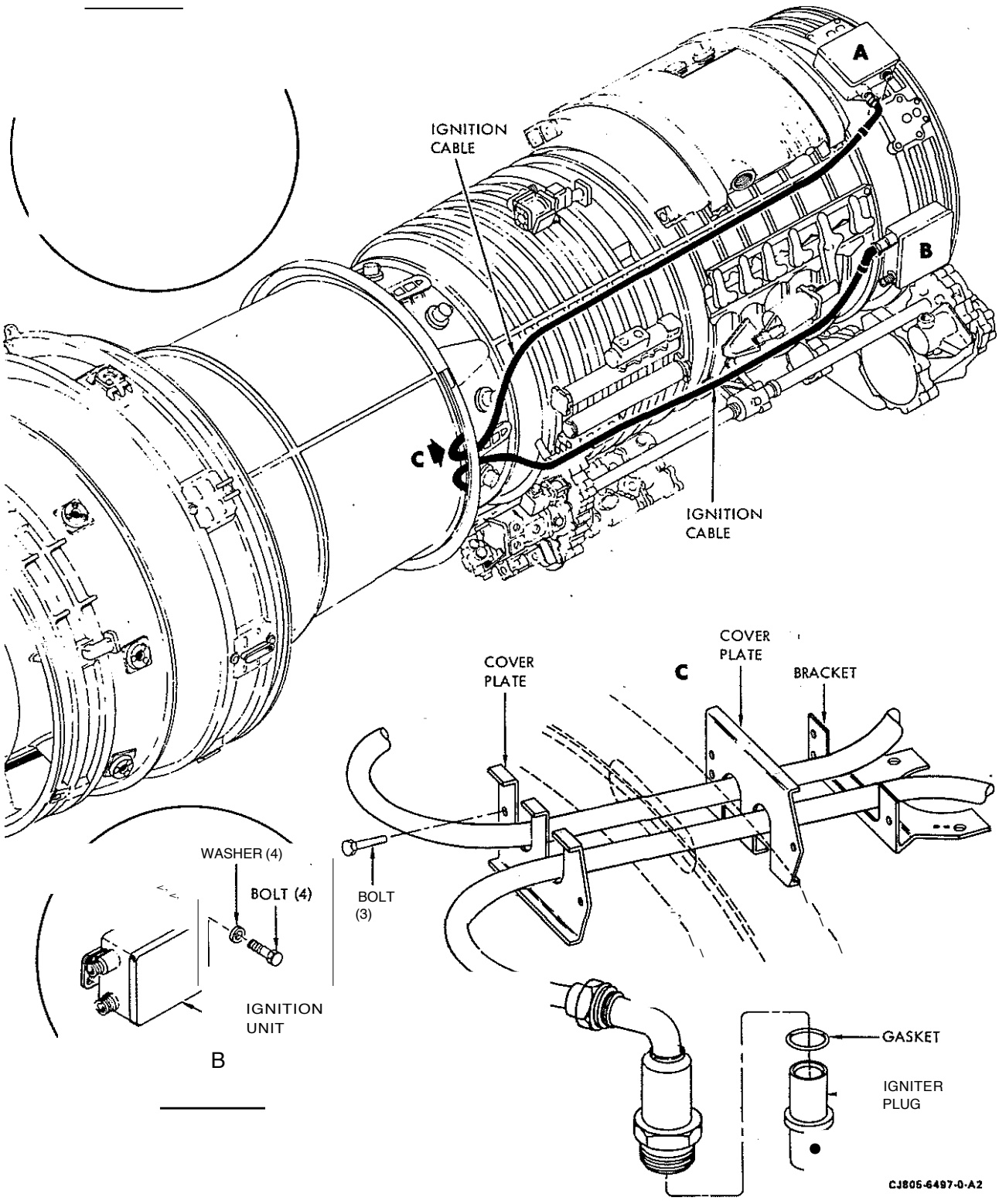
The ignition system contains two 14-joule ignition boxes, 2 igniter plugs and the high tension leads connecting the boxes and the plugs. The output of each circuit is 15-18 kv peak. (See figure 1.)

The engine ignition system components, their purposes and locations are listed in Table 1.

TABLE I - Ignition System Components

Component	**Purpose**	**Location**
Ignition Units	**Receive a-c power from the airframe power supply, convert the power into** high energy dc and discharge the dc to the -igniter plug.	2 o'clock and 4 **o'clock on the compressor front frame".**
Ignition Cables	**Transmits electrical power from the** ignition unit to the igniter plugs.	See figure 1.
Igniter Plugs	**Serves as a load for current dis-** charge by the ignition unit. Pro- **vides the spark necessary to ignite the fuel-air mixture in the combus- t ion liners.**	4 o'clock and 5 **o'clock on com- bustion outer** casing. (In for- ward end of No. 4 **and No. 5 com-** bustion liners).

The components form a capacitor-discharge ignition system. Power is supplied from the 115-volt, 400 cycle-per-second airframe bus to the ignition units. In the ignition unit, the a-c aircraft power is changed into 300-3400 volt pulsating direct current. The pulsating dc is fed into a tank capacitor which discharges approximately 2 times per second. The current discharged from the ignition unit is transmitted through the ignition cable to the igniter plug. An arc of short duration but high energy is produced, igniting **the fuel-air mixture. Aircraft-supplied, cockpit-mounted switches control** the power supply to the ignition system and permit alternate use of the cir- **cuits for starting.**



Ignition System
Figure 1

ENGINE IGNITION - TROUBLE SHOOTING

1. General. Ignition system troubles are generally easy to detect. However isolating the trouble to the individual components is sometimes more difficult. If replacement components are available, it is normally quicker and more economical to isolate the defective component by replacing parts with known good parts. The components most likely to malfunction are, first, the igniter plugs, then the ignition units.

Trouble-Shooting table is furnished in Section 72-0.

ENGINE IGNITION - MAINTENANCE PRACTICES

1. General. Maintenance of the system deals primarily with the components of the system. Since this information is given on the component level, this section will cover only routing and clamping.

   WARNING: THE IGNITION SYSTEM OPERATES AT DANGEROUSLY HIGH ELECTRICAL CURRENT. SHUT DOWN THE ENGINE PRIOR TO SERVICING THE SYSTEM. REMOVE THE INPUT CONNECTION TO THE IGNITION UNIT BEFORE DISCONNECTING OTHER CABLES.

2. Inspection/Check.

   A. Check for security of all components, brackets and bolts.

   B. Check for high voltage arc-through or shorts, indicated by burnt or severely discolored cable.

   C. Check for loose connections.

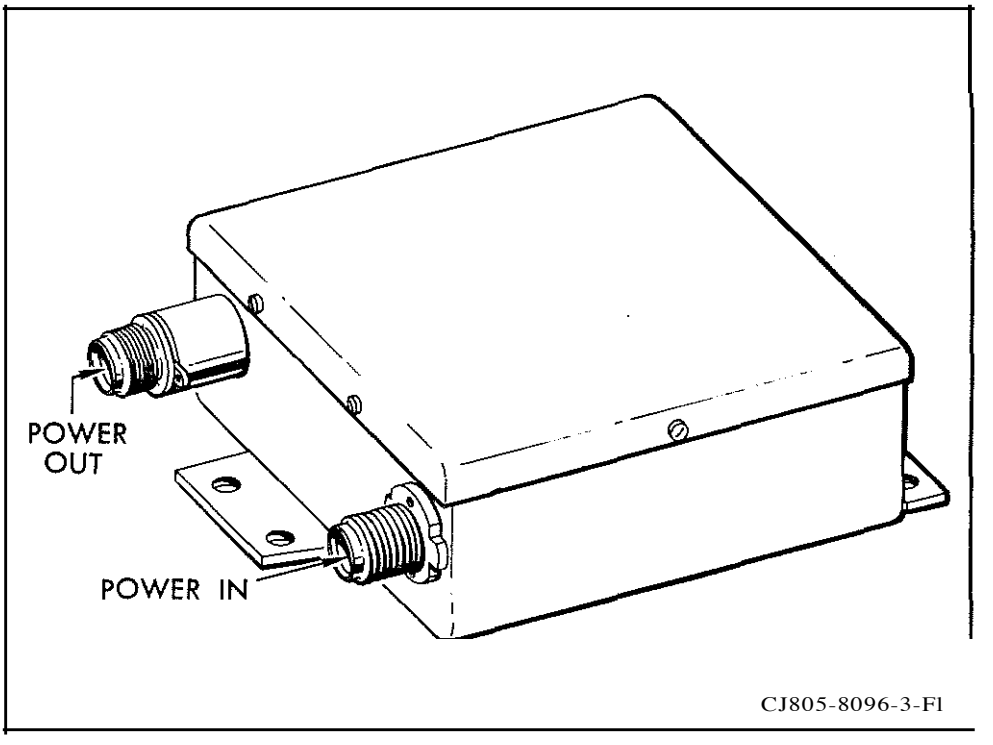
3. Approved Repairs.

   A. Tighten any loose components.

   B. Replace any component indicating shorts.

   C. Tighten loose connections.

IGNITION UNITS - DESCRIPTION



Ignition Unit
Figure 1

1. General. (See figure 1.) The ignition units receive aircraft power and discharge current in surges, approximately 2 times per second, through the high voltage output connector to the igniter plug. Table 1 lists the leading particulars of the ignition units.

TABLE 1. Ignition Unit Data

Input voltage	Normal ..... 115 volts, 400 cycle AC Operating limits ..... 90 to 120 volts
Spark rate	Normal L50 to 2.75 per second Operating limits •.•• 0.75 to 5.00 per second
Duty cycle •..•.••••....•..•.....	2 min. ON, 3 min. OFF 2 min. ON, 23 min. OFF

IGNITION UNITS - MAINTENANCE PRACTICES

1. General. Ignition unit maintenance is limited to removal/installation.

WARNING: THE IGNITION UNIT OPERATES AT VOLTAGE AND CURRENT LEVELS THAT ARE DANGEROUS. SHUT DOWN THE ENGINE PRIOR TO SERVICING THE IGNITION UNIT. REMOVE THE INPUT CONNECTION TO THE IGNITION UNIT BEFORE DISCONNECTING OTHER CABLES.

2. Removal/Installation. (See figure 201.)

A. Removal

(1) Disconnect low voltage cable (input-short neck connector).

(2) Disconnect high voltage cable (discharge-long neck connector).

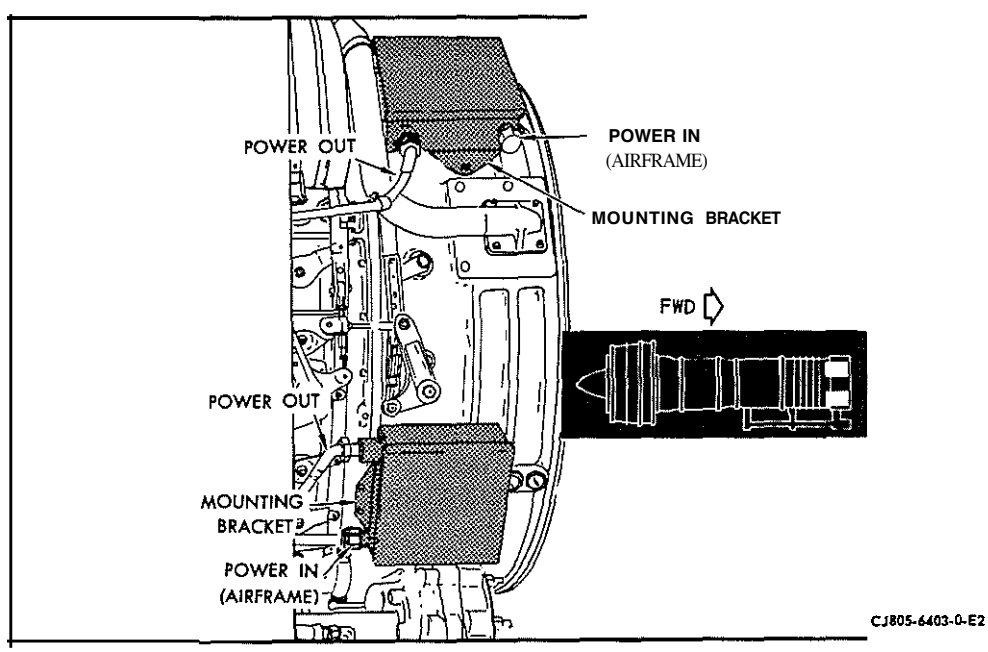
(3) Remove bolts holding the unit to compressor front frame, and lift unit from the engine.

B. Installation

(1) Position the unit on the compressor front frame, and secure with the mounting bolts. Torque per standard torque value.

(2) Attach high voltage cable to the long connector. Tighten to 160 + 10 Ib-in. Lockwire.

(3) Attach low voltage airframe cable to the short connector. Tighten and lockwire, according to airframe instructions.



Removal/Installation of Ignition Units
Figure 201

IGNITION CABLES - DESCRIPTION

1. General. The ignition unit output is applied to the input of the ignition cable. The cable then transmits the energy discharged from the ignition unit to the igniter plug.

   The cables are constructed in accordance with aircraft shielding practices. They are designed for operation under the following conditions:

Altitude	Up to 75,000 ft.
Ambient temperature	-65°F to 500°F.
Voltage	18,000 volts measured to ground at sea level.

IGNITION CABLES - MAINTENANCE PRACTICES

1. General. **Maintenance of ignition cables is limited to replacement, inspection and repair.**

2. Removal/Installation. (Reference figure 1, 74-2-0.)

A. Removal

(1) Remove the clamps securing the cable to the engine.

(2) Cut the lockwire, and disconnect the cable from the ignition unit.

(3) Remove the bolts that secure the cover plates to the spreader **bracket and remove the cover plates.**

(4) Loosen the nut which secures the cable connector to the combustion **casing boss and remove cable from the engine.**

B. Installation.

(1) Connect the cable to the combustion casing boss and ignition unit. Tighten to 160 + 10 lb-in.

CAUTION: DO NOT DAMAGE INSULATOR ENDS ON THE CABLE.

(2) Clamp the cable to the engine.

(3) Assemble the cover plates to the spreader bracket and install the bolts. Tighten to standard torque and lockwire.

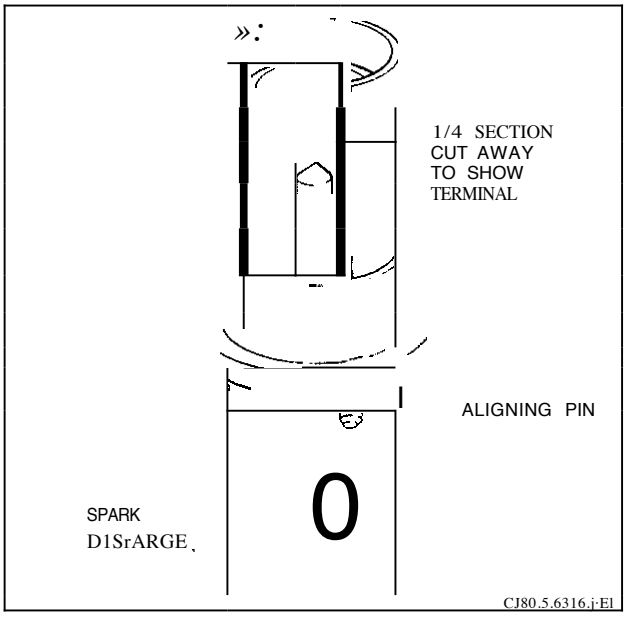
3. Inspection/Check.

A. Check the cables for frayed or torn braided conduit.

B. Check for damaged connectors.

4. Approved Repairs. Replace any damaged cables.

IGNITER PLUGS - DESCRIPTION



Igniter Plug
Figure 1

1. General. (See figure 1.) The igniter plug is a shunted-gap type which is self-ionizing and designed for low tension (relatively low voltage) applications. One plug is mounted in the forward end of the No.4 combustion liner; the other is mounted in the No.5 liner. Table 1 gives general information on the plug.

TABLE 1 - Igniter Plug Data

Ambient Temperature Range	-54°C to 593°C (-65°F to 1100°F)
Maximum Gas Temperature	1924°C (3500°F)
Plug Ionizing Potential	1000 volts dc
No Plug Part Deteriorated by .•..•....	Hydraulic fluid, lUbricating oils or commercial kerosene fuels.

IGNITER PLUGS - MAINTENANCE PRACTICES

1. General. Maintenance of the plugs is limited to replacement, adjustment/test, inspection/checks and repairs.

CAUTION: DO NOT ATTEMPT TO CLEAN THE FIRING END OF THE PLUG.

2. Removal/Installation. (See figure 1, 74-2-0.)

A. Removal.

(1) Loosen the nut which secures the igniter plug cable connector to the outer combustion casing. Pull the cable connector out of the combustion casing.

(2) Remove the igniter plug and gasket.

NOTE: Plug may come out when the connector is removed since the igniter plug is held in position by the connector.

B. Installation.

(1) Insert the plug into the combustion casing. The aligning pin on the plug must be inserted in the groove in the casing mounting boss for proper assembly. Install gasket on top of plug.

(2) Connect the connector of the ignition cable to the plug by pushing the connector into the outer combustion casing boss. Continue to push in on the connector, and thread the connector nut onto the boss.

NOTE: When making this connection do not release pressure until the threads are engaged. If pressure is released, the plug can move and the aligning pin become mis-aligned.

(3) Tighten the connector to 160 ± 10 lb-in., and lockwire.

3. Adjustment/Test. Whenever an igniter plug shows signs of damage to the shield on semi-conductor it should be checked for proper operation.

A. Connect the igniter plug to the ignition cable and place the plug in a clear plastic container.

B. Energize the ignition system so the plug will fire.

C. Check the arc for proper firing. The arc should be from the tip of the center electrode to the end of the metal shield. If arc appears on any other part of the plug the plug should be replaced.

4. Inspection/Checks. When the igniter plug is removed, make the following checks:

NOTE: If the plug shows damage to either the shield or semi-conductor the plug should be checked for proper operation per the adjustment/test **in this section. If the plug meets the condition specified, it is serviceable.**

A. Check for damaged or crossed threads.

B. Check metal shield around firing end for excessive wear, cracks, grooves, or burning.

C. Check semi-conductor for chips or cracks.

5. Approved Repair. Replace any damaged plug.

NOTE: Do not attempt to straighten bent connector pins.

75-20 ENGINE AIR FLOW
Description and Operation 1

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75-21-2 Engine Anti-Icing Temperature Regulating Valve
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75-21-3 Anti-Icing Pressure Switch
Description and Operation 1
Maintenance Practices 201
Removal/Installation 201

A. Seventh-stage air flows into the center of the compressor rotor and through the stub shafts into the center of the turbine rotor. This air tends to equalize the pressure differential across the discs, spacers and turbine rotor shaft, and serves a cooling function. A small amount of air flows into the No. 1 bearing interseal area to pressurize the sump. The remainder of this air flows outward through all struts (except strut 5) of the fan front frame and heats the 2 "hat" sections which encircle the outside of the frame.

B. Ninth-stage air is bled from a manifold around the upper half of the compressor rear casing and is routed to the interstage seal areas of the No.2, No.3, No.4 and No.5 bearing sumps. The air bleeds across the seals to pressurize the sumps.

C. Some air bleeds through the 17-stage air seal. A portion of this air bleeds through holes in the discs of compressor stages 11 through 17. This air tends to equalize the pressure across the spacers, torque cones and discs and also offsets the normal aft thrust of the rotors. The remainder of the air is discharged through struts No.3, 8 and 10 of the compressor rear frame.

D. Compressor bleed air is discharged from struts No.2, 4, 7 and 9 of the compressor rear frame. The airframe bleed air manifold is attached to pads over these struts. A portion of the air from the bleed manifold is routed to the fuel heater where it is used to heat engine fuel if icing conditions exist. The remainder of the air is used for airframe purposes.

E. A portion of the main airflow bleeds through holes in the inner combustion casing and the outer rims of the first- and second-stage turbine nozzles. This air cools the turbine shaft, the shank sections of the first-stage turbine buckets and the first- and second-stage nozzle partitions.

F. Air discharged from the 17th-stage of the compressor is ducted through a port on the compressor rear frame and routed externally to the compressor front frame. This air anti-ices the front frame struts and hub, the inlet guide vanes, the, CIT sensor probe, and the airframe-furnished nose cone.

G. A portion of the primary exhaust flow is ducted out through all struts except the top and bottom struts of the fan front frame. This air anti-ices the leading and trailing edges of the portion of the struts that extends through the fan airstream.

NOTE: On engines with a blucket shield that is located under the thrust reverser tubing there is an engine power reduction system which utilizes the CDP signal air.

ANTI-ICING AIR SYSTEM - DESCRIPTION AND OPERATION

1. General. Engine bleed air is used to anti-ice the engine inlet. Turbine exhaust gas is used to anti-ice the fan inlet. Figure 1 of 75-20 shows the external routing of air. The following paragraphs describe the 2 sub-systems.

2. Engine Inlet Anti-Icing. The engine anti-icing system prevents the accumulation of ice of the compressor front frame and the inlet gUide vanes. The flow of air is regulated by the anti-icing temperature regulating valve. The system is turned on and off by a solenoid operated shut-off valve. Operation is controlled by the pilot.

   When the pilot energizes the solenoid in the anti-icing shut-off valve by actuating the cockpit switch, the valve permits anti-icing airflow to the temperature regulating valve. The. temperature regulating valve maintains safe operating air temperature within the engine front frame. The air flows forward through a manifold to struts No.2, 3, 7 and 8 of the front frame. The air flows through the struts into the hub of the frame. From the front frame hUb, air flows through the hollow inlet gUide vanes and out through the 4 other struts. The air is discharged into the main air stream through holes near the outer ends of the struts and the trailing edge of the vanes. Figure 1 of 75-20 shows the external routing of engine anti-icing air. Some air flows through a port on the forward side of the hub and is used to anti-ice the air-**frame nose cone fairing.**

3. Fan Inlet Anti-Icing. A portion of the turbine exhaust gas is bled through holes in the inner strut baffles and flows into the mid hat section of the fan front frame. The air then flows outward through the leading and trailing edges of struts No.2, 3, 4, 6 7 and 8 of the fan front frame. This air anti-ices the struts and is vented to the fan airstream through 2 holes near the outer end of each strut. Strut No. 1 and strut No.5, the top and bottom struts do not require anti-icing. since they are covered by the fan inlet duct pylons and, thus, are not SUbjected to icing conditions.

ANTI-ICING AIR SYSTEM - TROUBLE-SHOOTING

1. General. Anti-icing system troubles fall into 2 categories, engine or airframe. Little trouble-shooting is required, but correct diagnosis is essential.

Trouble-Shooting table is furnished in Section 72-0.

ANTI-ICING AIR SYSTEM - MAINTENANCE PRACTICES

1. General. Maintenance of the system is limited to the external piping, the anti-icing valve, the temperature regulating valve and the pressure switch. Maintenance of the anti-icing valve, temperature regulating valve and pressure switch is described in 75-21-1, 75-21-2 and 75-21-3 respectively.

2. Removal/Installation. The components of the system can be disconnected by conventional means; however the removal of the manifolds is hampered by the pod. Removal of the valves and pressure switch is described in the applicable sections.

3. Adjustment/Test. Although no adjustment can be made, it may be desirable to test the system for proper operation.

   NOTE: For ground checking,the engine may be operated with the anti-ice system on, or suspected to be on, with a compressor inlet temperature above 15°C (59°F) for a period not to exceed five minutes at any power setting, inclUding take-off power, and for 20 minutes at idle power.

   A. Correct operation of the anti-icing system is indicated as follows:

      (1) Between idle and 70% RPM with the engine anti-icing switch ON, the system malfunction light will be ON.

      (2) Above 75% RPM, with the engine anti-icing switch ON, the system malfunction light should be OFF.

4. Inspection/Check of Manifolds.

   A. Check the manifolds for cracks. None allowable.

   B. Check all manifold pad connections for blown gaskets.

   C. Check for loose manifold connections.

   D. Check for loose clamps.

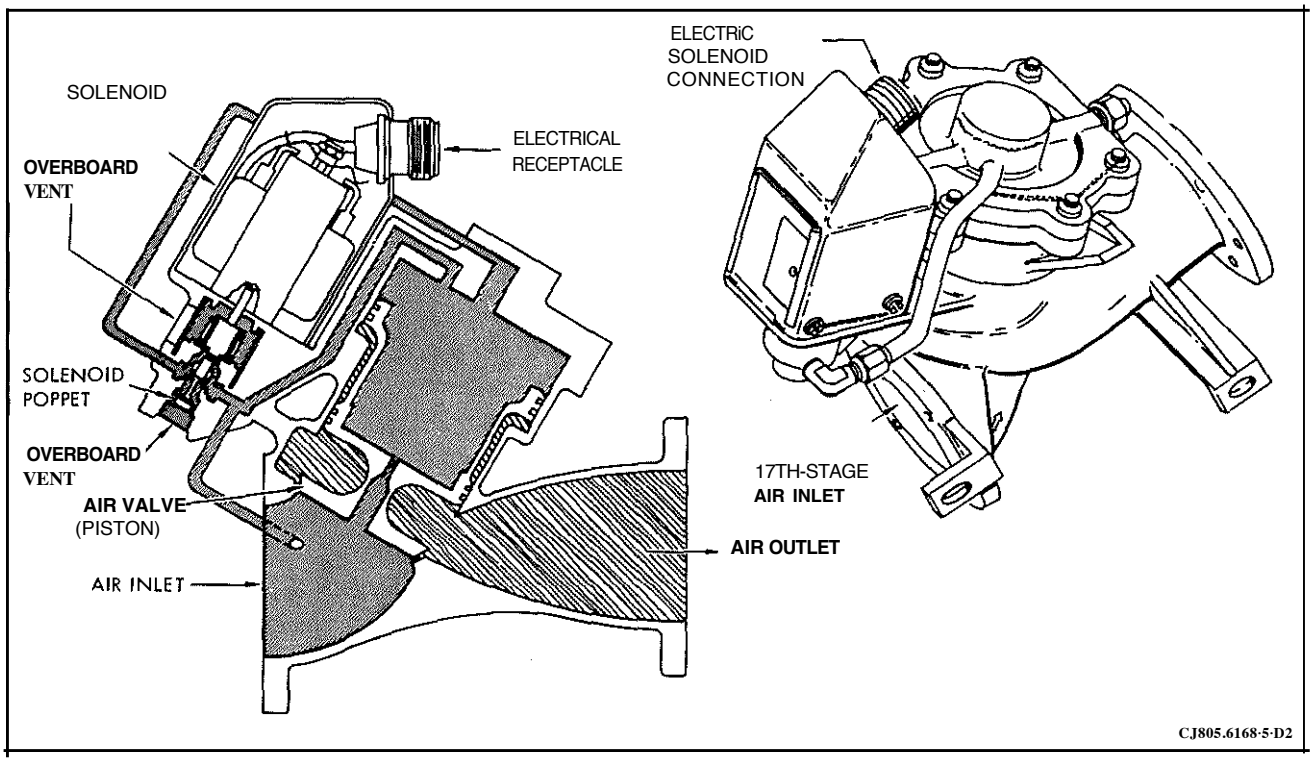
   Approved Repair.

   A. Replace cracked manifolds.

   B. Replace any blown gaskets.

   C. Tighten any loose connections or clamps.

ANTI-ICING VALVE - DESCRIPTION AND OPERATION



Anti-Icing Valve
Figure 1

1. General. The anti-icing air shut-off valve controls the supply of 17th-stage compressor air for anti-icing of the compressor front frame.

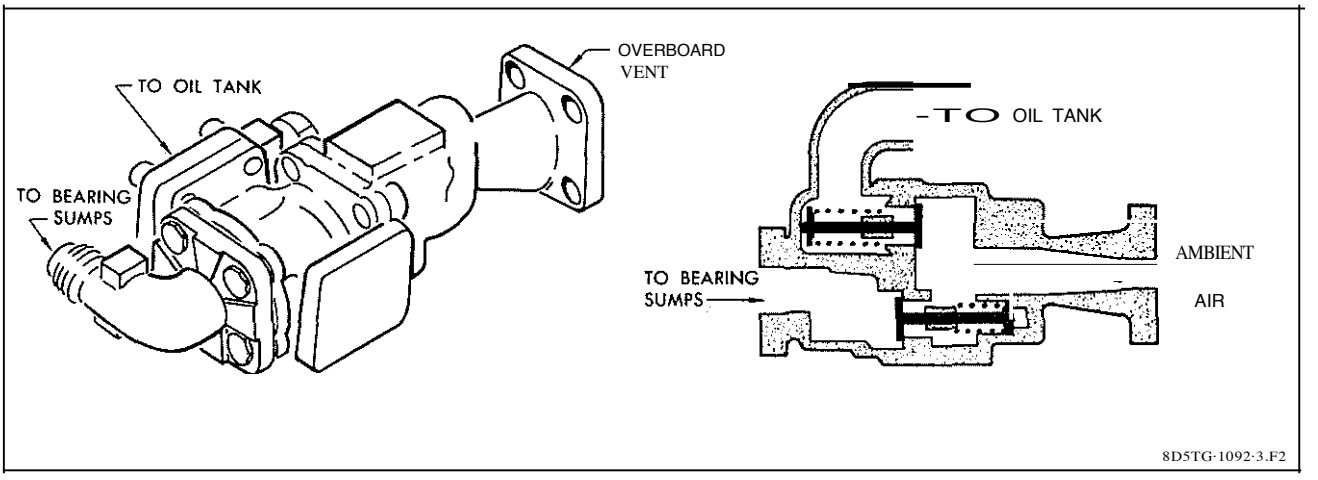
2. Valve Operation. (See Figure 1.)

   A. System Off. When the anti-ice switch is in the OFF position the solenoid is de-energized with the solenoid poppet and the main valve closed. The interior of the piston is pressurized (CDP air). The main valve (piston) remains in the closed position due to the difference in area between the main valve face and the piston interior, the area of the latter being twice that of the valve face.

   B. System On. When the anti-ice switch is in the ON position, the solenoid is energized, opening the solenoid poppet valve. When the solenoid is opened, the pressurized air in the piston interior is dumped overboard. As pressure on the top of the piston decreases, CDP air acting on the main valve face opens the air valve and permits air flow through the valve into the compressor front frame anti-ice system.

      NOTE: The anti-icing air shut-off valve solenoid is powered by 110 volts, 400 cps.

SUMP AND TANK PRESSURIZING VALVE - DESCRIPTION AND OPERATION

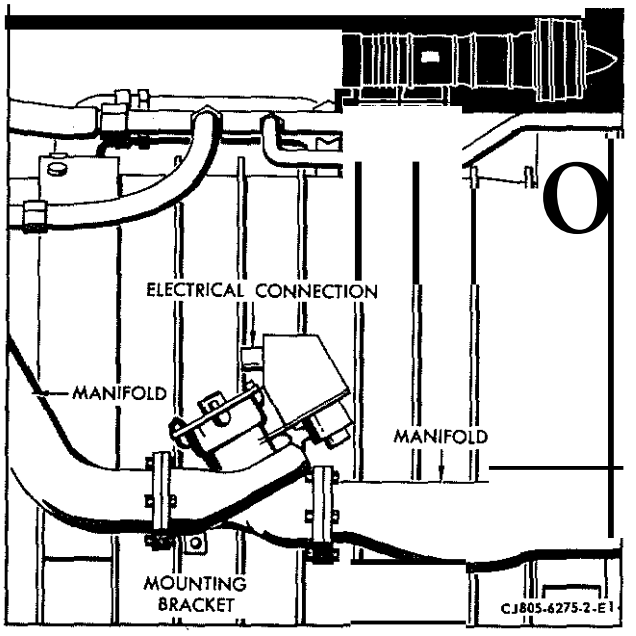


Sump and Tank Pressurizing Valve
Figure 1

1. General. The sump and tank pressurizing valve maintains the proper air pressure in the oil tank, the gearboxes, and the engine bearing sumps. This is accomplished by admitting ambient air to the sumps or venting air overboard through a pair of check valves.

   The tank vent valve opens when pressure in the tank rises to 3-4 psi above ambient pressure and is capable of passing enough air to keep tank pressure from exceeding 6 psi above ambient pressure. The sump check valve opens when pressure in the sumps falls below 2-3 psi below ambient pressure and is capable of drawing enough air in to keep system pressures from falling below 4 psi below ambient pressure.

ENGINE ANTI-ICING SHUT-OFF VALVE - MAINTENANCE PRACTICES



Removal/Installation of Engine Anti-Icing Valve
Figure 201

1. General. Engine anti-icing shut-off valve maintenance consists of Removal/ Installation, with only minor repair.

2. Removal/Installation of Valve. (See figure 201.)

A. Removal of Valve.

(1) Disconnect the airframe electrical lead from the solenoid.

(2) Cut the lockwire, and remove the bolts and washers that connect the manifolds to the valve.

(3) Remove the bolts from the mounting feet and remove the valve.

B. Installation of Valve.

NOTE: During the following operations, care should be taken to see that the best possible alignment of the valve and manifolds is maintained.

(1) Loosely secure the manifold clamps and mounting brackets to the engine, and the valve to the mounting brackets.

(2) Install new gaskets between the manifolds and the valve, and secure with bolts and washers. Apply small amount of Crane Compound Formula No. 425 onto the threads of the bolts. Torque and lockwire.

(3) Torque the bolts **mounting** the brackets to the **engine.**

(4) Torque the bolts mounting the valve to the brackets.

(5) Torque the bolts **securing** the manifold clamps.

(6) Connect the electrical **connection to the valve.** Torque to 160 ± 10 Lb-d.n,, and lockwire.

3. Inspections/Check of Valve.

A. Check for cracks in the valve body and the mounting feet.

B. Check manifold flanges for nicks and scratches.

C. Check electrical connector for bent or dirty pins.

D. Deleted.

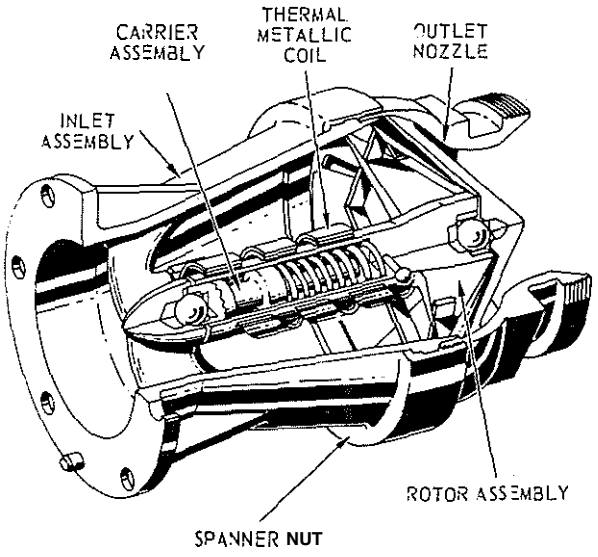
4. Approved Repair.

A. Replace any valve that has cracks in casting.

B. Dress out nicks and scratches in the manifold flanges.

C. Wipe dirt off of pins in electrical connection. Do not attempt to straighten bent pins.

ANTI-ICING TEMPERATURE REGULATING VALVE - DESCRIPTION AND OPERATION



Anti-Icing Temperature Regulating Valve
Figure 1

1. General.

A. The Anti-Icing Temperature Regulating Valve is a temperature-actuated valve which is designed to utilize compressor discharge temperature (CDT) as a parameter to control engine anti-icing air flow. It is mounted in-line in the anti-icing air line and meters air through itself as a function of the air temperature. The valve consists basically of inlet, rotor and carrier assemblies and an outlet nozzle. The rotor assembly, which **contains a set of flow control vanes and a thermal metallic coil, is sus**pended between the inlet assembly and the outlet nozzle by a set of carbide balls. The carrier assembly spring-loads this suspension to provide compensation for differences in thermal expansion.

B. The flow control vanes of the rotor assembly control the flow area through the windows formed by the conical surfaces of the outlet nozzle. As the temperature of the air flowing through the valve changes, it will cause a deflection of the thermal metallic coil of the rotor assembly. This will create a rotational repositioning of the rotor assembly to adjust the flow area accordingly. As the air temperature increases, the **flow area is reduced; as the air temperature decreases, the flow area is** increased. Thus the engine inlet components will receive adequate air at the proper temperature for anti-icing without risk of damage to the components due to excessively high temperatures.

ENGINE ANTI-ICING TEMPERATURE REGULATING VALVE - MAINTENANCE PRACTICES

1. General. Engine anti-icing temperature regulating valve maintenance consists of Removal/Installation, with only minor repair.

2. Removal/Installation of Valve.

   A. Removal of Valve.

      (1) Cut the lockwire and remove the 6 flange mounting bolts at the rear of the valve.

      (2) Cut the lockwire on the front coupling. Using a wrench to hold the valve securely, loosen and remove the manifold coupling nut and remove the valve.

   B. Installation of Valve.

      (1) Loosely secure the manifold coupling nut to the front of the valve.

      (2) Install a new gasket between the rear of the valve and the manifold collar flange. Position the valve so that the name plate is up. Align the valve flange, manifold collar flange and engine bracket and install the 6 mounting bolts.

      Apply a small amount of Crane Compound Formula No. 425 onto the thread or the oolts. Torque and lockwire.

      NOTE: The 2 longer bolts must be used to pass through the mounting bracket.

      (3) Using a wrench to hold the valve body, torque and lockwire the front manifold coupling nut.

3. Inspection/Check of Valve.

   A. Check for cracks in the valve body.

   B. Check valve coupling nut for security.

   C. Check manifold flanges and threads for necks and scratches.

4. Approved Repair.

   A. Replace any valve that has cracks in the casting.

   B. Dress out nicks and scratches in the manifold flange and threaded end.

   C. Replace broken or stretched lockwire on the valve coupling nut.

ANTI-ICING PRESSURE SWITCH - DESCRIPTION AND OPERATION

NOTE: The anti-icing pressure switch is airframe supplied.

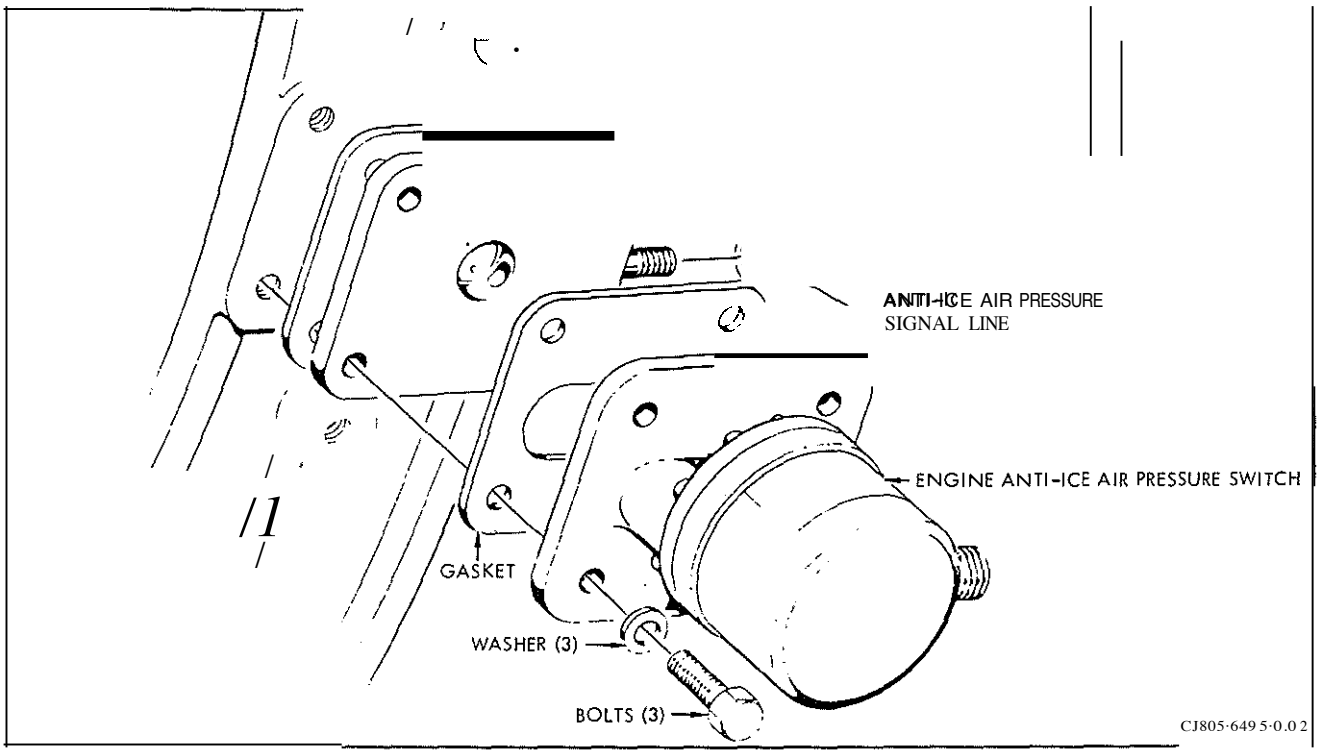
1. General.

The engine anti-icing pressure switch mounts on a sandwich fitting on the engine compressor front frame strut No.6. Air is tapped off the engine anti-ice air manifold between the engine air shutoff and temperature regulating valves, and routed through a tube to the sandwich fitting. The sWitch actuates at 9 (±l) psig air pressure.

ANTI-ICING PRESSURE SWITCH - MAINTENANCE PRACTICES

NOTE: The anti-icing pressure switch is airframe supplied.

1. General. Maintenance of the pressure switch consists of Removal/Installation.



Anti-Icing Pressure Switch
Figure 201

2. Removal/Installation. (See figure 201.)

A. Removal.

(1) Disconnect electrical plug from switch receptacle.

(2) Disconnect anti-ice air pressure signal line from sandwich fitting.

(3) Cut safety wire and remove holts; remove pressure switch, sandwich fitting and two gaskets.

B. Installation.

(1) Place gasket, sandwich fitting, gasket and switch (in that order), with tube connection on sandwich fitting and receptacle on switch **facing aft, in position on engine compressor front frame, and install**

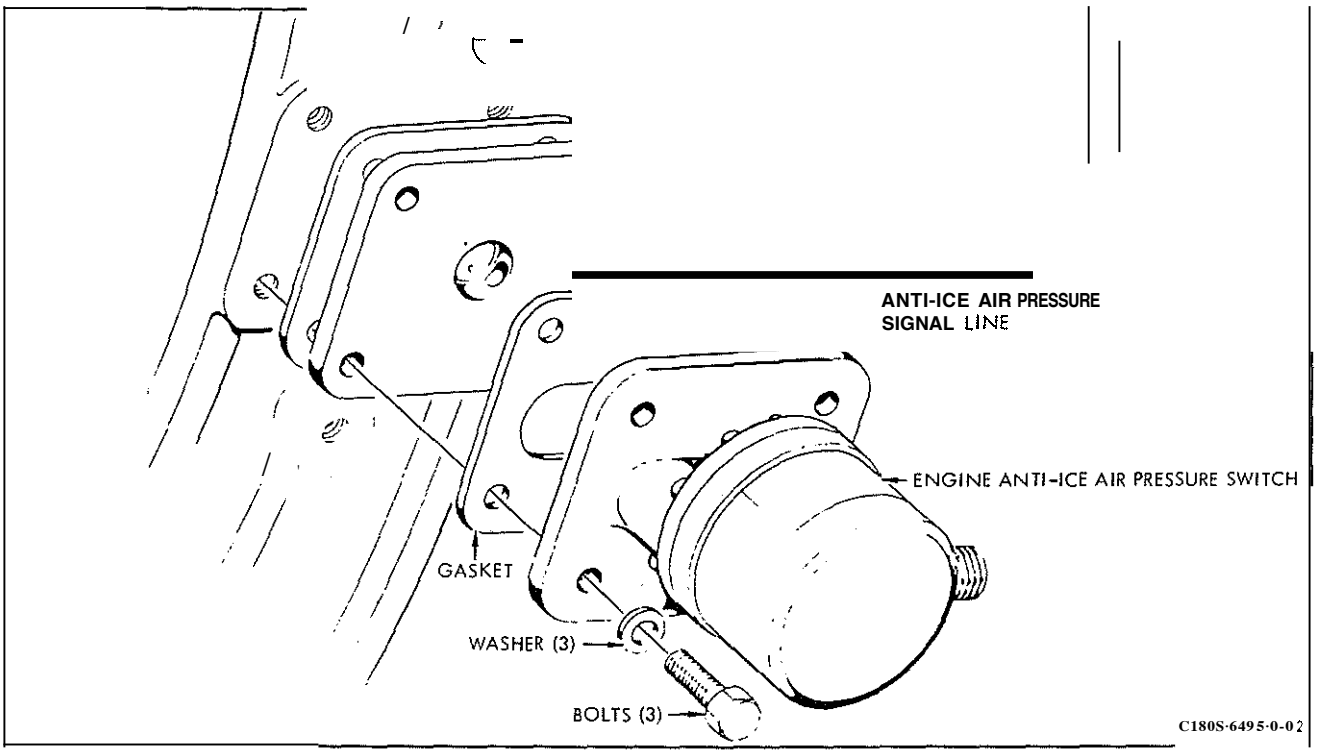
four bolts and washers (washers under bolt heads); attacb wire support bracket with lower aft bolt. Tighten bolts and install safety wire.

CAUTION: ENSURE THAT SIDE OF SANDWICH FITTING HAVING 0.025-INCH DIAMETER HOLE IS INSTALLED TOWARD ENGINE COMPRESSOR FRONT FRAME.

ANTI-ICING PRESSURE SWITCH - MAINTENANCE PRACTICES

NOTE: The anti-icing pressure switch is airframe supplied.

1. General. Maintenance of the pressure switch consists of Removal/Installation.



Anti-Icing Pressure Switch
Figure 201

2. Removal/Installation. (See figure 201.)

A. Removal.

(1) Disconnect electrical plug from switch receptacle.

(2) Disconnect anti-ice air pressure signal line from sandwich fitting.

(3) Cut safety wire and remove bolts; remove pressure switch, sandwich fitting and two gaskets.

B. Installation.

(1) Place gasket, sandwich fitting, gasket and switch (in that order), with tube connection on sandwich fitting and receptacle on switch facing aft, in position on engine compressor front frame, and install

four holts and washers (washers under bolt heads); attach wire support bracket with lower aft bolt. Tighten bolts and install safety wire.

CAUTION: ENSURE THAT SIDE OF SANDWICH FITTING HAVING 0.025-INCH DIAMETER HOLE IS INSTALLED TOWARD ENGINE COMPRESSOR FRONT FRAME.

ENGINE INDICATING SYSTEM - DESCRIPTION AND OPERATION

1. General. (See Figure 1.) The majority of the indicating circuits are airframe supplied. In these cases provisions have been made on the engine to install the indicating transducers and/or probes. However, General Electric does supply the components which generate signals to 4 airframe-indicating circuits. They are engine speed, fan speed, exhaust gas indicating circuits and engine total pressure system.

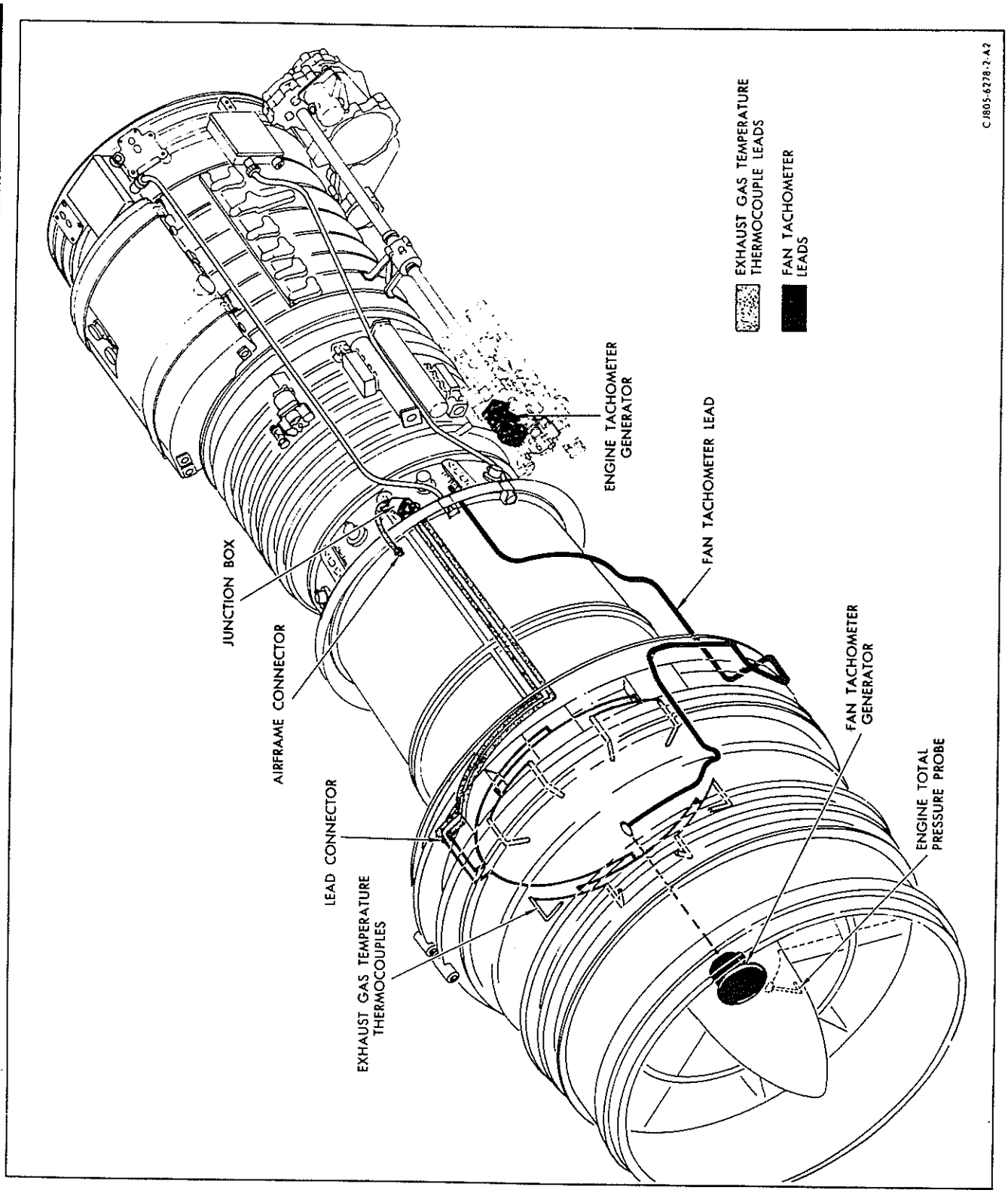
2. Engine Speed Indication. The engine speed indicating equipment (Figure 1) consists of the tachometer generator. Frequency output of the tachometer generator varies linearly with engine speed. The resulting signal is transmitted through an airframe-furnished electrical lead to the cockpit tachometer indicator.

3. Fan Speed Indication. The aft fan indicating circuit consists of a tachometer gearbox and leads, both engine and airframe, that connect to a cockpit indicator. The tachometer generator is bolted to the support cone at the hub of the fan rear frame and is coupled, by a spline, directly to the fan rotor. A lead is connected to the generator and is routed out through a strut in the fan rear frame and forward to the firewall where the aircraft leads are attached.

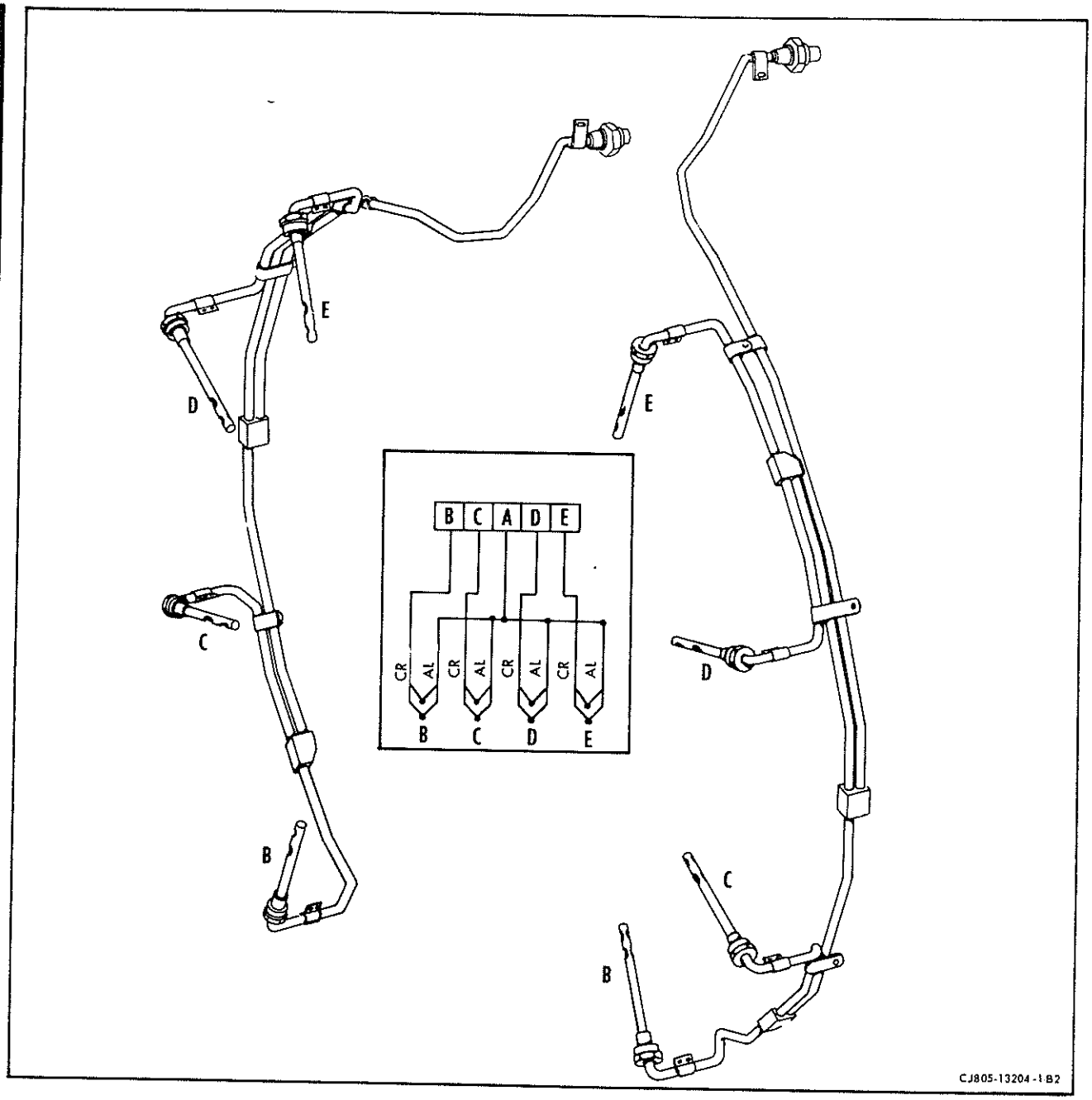
4. Exhaust Gas Temperature (EGT) Indication. (See Figure 2.) The exhaust gas temperature-indicating circuit consists of 8 dual-immersion thermocouples attached to 2 half-ring harnesses. Each harness half has 4 equally-spaced probes capable of providing separate output signals. The thermocouple probes are of the dual type with each probe having two junctions. The junctions are located along the probe length approximately two inches apart, and are connected in parallel at the junction box. In each harness the 4 probes are connected so each has one common lead (pin A) and an individual lead (pins B, C, D and E) that are routed to a connector. (This permits reading of the individual probes.) From these connectors a pair of leads run forward and through the firewall to the junction box.

5. Engine Total Pressure Indication. The engine total pressure indication system consists of a probe that extends out through the inner hub of the fan rear frame and into the gas stream of the main engine. This probe connects to inner end of the number 6 strut of the frame. The strut passage transmits the pressure to the outside of the frame. The pressure is used in the aircraft engine pressure ratio indicating system.

6. Deleted.



Engine Indicating System
Figure 1



Thermocouple Harness
Figure 2

ENGINE INDICATING SYSTEM - TROUBLE-SHOOTING

1. General. If trouble occurs in the indicating system, it is important to be sure that all connections are secure and correctly made. Because the system consists of only 1 engine-furnished components in each sub-system establishing whether the malfunction is an engine or an airframe fault is relatively simple.

Trouble-Shooting table is furnished in Section 72-0.

ENGINE INDICATING SYSTEM - TROUBLE-SHOOTING

1. General. If trouble occurs in the indicating system, it is important to be sure that all connections are secure and correctly made. Because the system consists of only 1 engine-furnished components in each sub-system establishing whether the malfunction is an engine or an airframe fault is relatively simple.

2. Engine Speed Indicating System.

A. Engine Speed Indication High:

Possible Causes	Isolation Procedures	Correction
(1) Faulty indicator	Refer to Aircraft Instructions.	Refer to Aircraft Instructions.
(2) Engine top speed improperly set	Refer to 73-1-4	Adjust.

B. No Engine Speed Indication:

Possible Causes	Isolation Procedures	Correction
(1) Tachometer generator shaft sheared		Replace tachometer generator. (Refer to 77-21-1.)
(2) Defective tachometer generator		Replace tachometer generator. (Refer to 77-21-1.)
(3) Defective aircraft circuitry	Refer to Aircraft Procedure.	Refer to Aircraft Instructions.
(4) Defective indicator	Refer to Aircraft Procedure	Refer to Aircraft Procedure.

C. Erratic Engine Speed Indications:

Possible Causes	Isolation Procedures	Correction
(1) Loose connections (aircraft only)	Refer to Aircraft Procedures.	Refer to Aircraft Instructions.
(2) Defective tachometer generator	Disconnect tachometer leads and check continuity of tachometer. Check between pins A and B, pin A to connector and pin B to connector. Resistance should not exceed 60 ohms.	Replace tachometer.

Possible Causes	Isolation Procedure	Correction
(3) Worn drive shaft spline on tachometer generator	Remove and inspect tachometer generator.	If spline is excessively worn, replace tachometer generator.

3. Fan Speed Indicating System.

A. Fan Speed Indication High:

Possible Cause	Isolation Procedure	Correction
(1) Faulty indicator	Refer to Aircraft Instructions.	Refer to Aircraft Instructions.
(2) Engine top speed improperly set	Refer to 73-1-4.	Adjust.

B. No Fan Speed Indication

Possible Cause	Isolation Procedure	Correction
(1) Defective aircraft dircuitry	Refer to Aircraft Procedure	Refer to Aircraft Procedure.
(2) Defective indicator	Refer to Aircraft Procedure	Refer to Aircraft Procedure.
(3) Tachometer shaft sheared	Look for oil leakage from fan rear frame. (The No. 5 bearing scavenge pump is driven by tachometer.)	Replace tachometer.
(4) Short in wire in electrical circuit of fan rear frame	Check continuity at outer end of electrical strut.	Replace cable inside of tail cone.
(5) Faulty aircraft wiring/indicator	Refer to Aircraft Instructions.	

C. Erratic Fan Speed Indications:

Possible Cause	Isolation Procedure	Correction
(1) Loose connections at tachometer	Check connections at tachometer and inner strut.	Tighten connectors.

	Possible Cause	Isolation Procedure	Correction
(2)	Loose connections (airframe)	Refer to Aircraft Procedures.	Refer to Aircraft Procedures.
(3)	Worn drive shaft spline on tachometer generator or coupling	Remove and inspect tachometer generator.	Replace tachometer generator or coupling if beyond limits.
(4)	Short in wire in electrical circuit of fan rear frame	Check continuity at outer end of electrical strut.	Replace cable inside of tail cone.
(5)	Faulty aircraft wiring/indicator	Refer to Aircraft Instructions.	

4. Exhaust Gas Temperature System.

A. Inaccurate EGT Indication:

Possible Causes	Isolation Procedure	Correction
(1) Faulty indicator	Refer to Aircraft Instruction.	Refer to Aircraft Instruction.
(2) Shorted Thermocouple	Check thermocouples in each harness by checking each pin in the connector to ground; resistance should be 1000 ohms minimum.	Replace defective thermocouple harness. (Refer to 77-21-3.)
(3) Thermocouple opening during operation.	(Refer to 77-21-3 Adjustment/Test)	Replace defective harness.

B. No EGT Indication:

Possible Causes	Isolation Procedure	Correction
(1) Broken thermocouple circuit (engine)	Disconnect and check the single lead (located in front of firewall) for continuity.	Replace lead.
(2) Shorted thermocouple lead.	Disconnect and check continuity of both solid and flexible lead.	Replace defective lead.
(3) Shorted thermocouple	Check thermocouples in each harness by checking each pin in the connector to ground; resistance should be 1000 ohms minimum.	Replace defective thermocouple harness. (Refer to 77-21-3.)

C. Erratic EGT Indications:

Possible Causes	Isolation Procedure	Correction
(1) Loose connections (engine)	Check connectors at fan front frame and in front of firewall	Tighten connector
(2) Loose connections (aircraft)	Refer to Aircraft Procedure	Refer to Aircraft Procedure

5. Engine Total Pressure System.

A. Little or No Pressure From Probe.

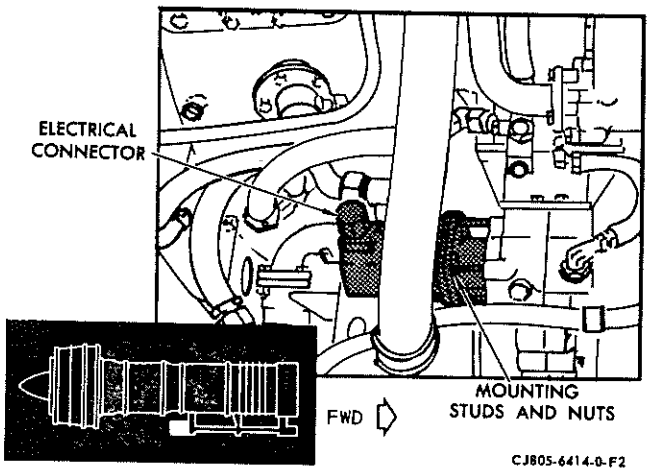
Possible Cause	Isolation Procedure	Correction
(1) Probe bent or twisted	Inspect visually	Replace probe
(2) Clogged probe or strut tube	Check probe visually check strut by blowing through it	Replace or clean probe clean strut tube.
(3) Cracked strut tube.	Pressure check tube (Refer to 72-6-4)	Replace engine or repair crack.

B. Negative Pressure From Probe.

Possible Cause	Isolation Procedure	Correction
(1) Broken or missing probe	Inspect visually	Replace probe.

TACHOMETER GENERATOR - MAINTENANCE PRACTICES

1. General. Maintenance of the tachometer generator is limited to removal/installation.



Removal/Installation of Engine Tachometer Generator
Figure 201

2. Removal/Installation. (See figure 201.)

A. Removal.

(1) Disconnect the generator output lead.

(2) Remove nuts that hold the generator to the airframe load cut switch.

(3) Remove the generator from the engine.

B. Installation.

(1) Assemble new gasket to mounting pad. Coat drive spline of tachometer with Plastilube Moly No. 3 (Warren Refining Co., Cleveland, Ohio 44102), Molylube 503 Grease (Bel-Ray Co., Inc., P.O. Box 526, Farmingdale, N.J. 00727) or General Purpose Moly No. 3, (Southwest Grease and Oil Co., Wichita, Kansas 67201) or equivalent. Insert spline of tachometer into mating spline of rear gearbox.

(2) Rotate generator to align bolt holes.

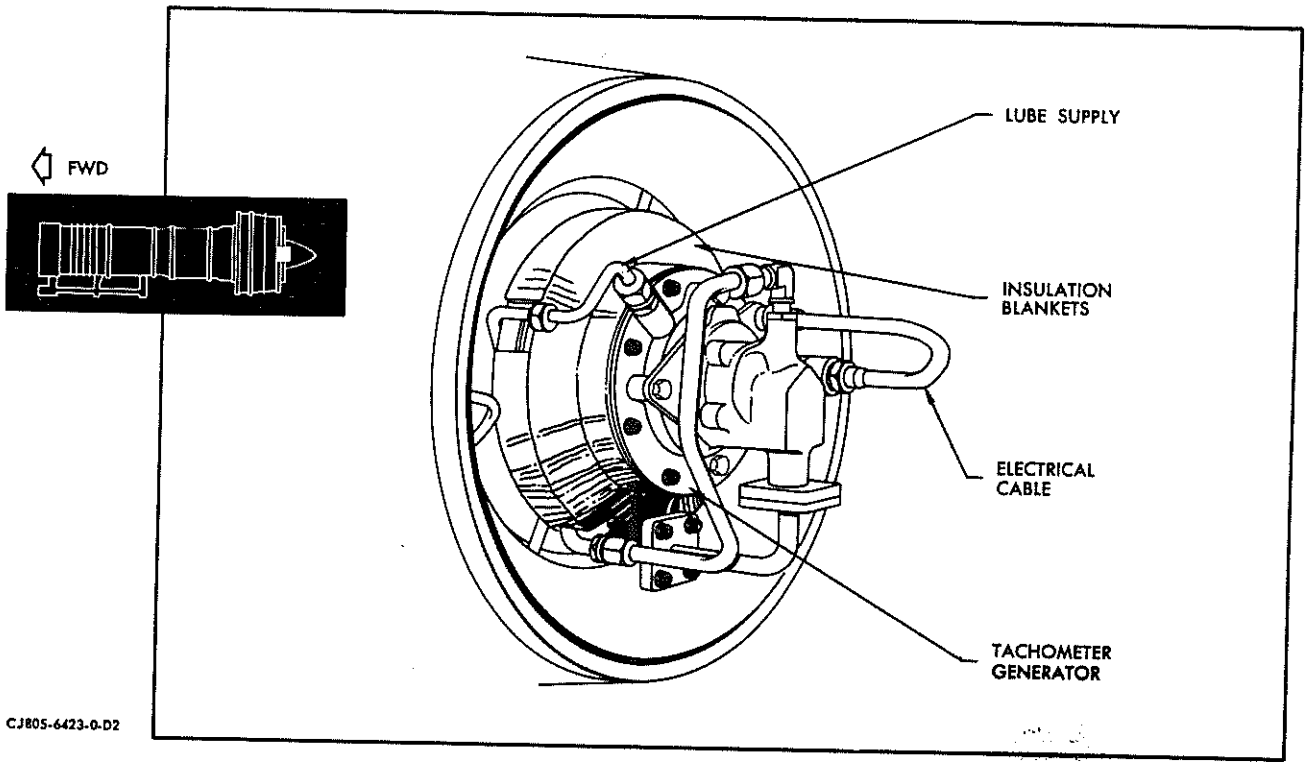
(3) Install mounting nuts. Tighten to standard torque value, and lockwire.

(4) Connect generator output lead. Torque, per aircraft instructions.

(5) Check and calibrate system. (Refer to aircraft instructions.

AFT FAN TACHOMETER GENERATOR - MAINTENANCE PRACTICES

1. General. Maintenance of the fan tachometer generator is limited to removal/installation.



Removal/Installation of Fan Tachometer Generator
Figure 201

2. Removal/Installation. (See figure 201.)

NOTE: The inner exhaust cone must be removed for the procedure. Refer to 78-0 for inner exhaust cone removal and installation.

A. Removal

(1) Remove the No. 5 bearing scavenge pump. (Refer to 72-5-6.)

(2) Remove the insulation blankets from the lines and generator.

(3) Remove the tachometer generator electrical cable by removing the clamp and disconnecting at the tachometer and the electrical strut.

NOTE: The clamp that holds the cable covers the hexagonal wrench flats on the strut connection. The clamp must be removed to permit the use of a wrench on these flats when the cable is being disconnected at the strut end.

(4) Remove the tachometer generator lube supply tube by disconnecting it at the tachometer and at the connector tube at the sump.

(5) Remove the tachometer generator by removing the bolts securing it to the adapter in the frame.

B. Installation

(1) Place the tachometer generator, with a new gasket on the adapter in the frame. Secure in place with bolts; torque.

(2) Install the insulation blankets on the generator.

(3) Connect the tachometer generator lube supply line to the generator and the connector tube at the sump.

(4) Connect the tachometer generator electrical cable to the generator and the connector at electrical strut. Tighten connectors to 275 to 300 lb. ins. and install clamp.

(5) Install the insulation blankets on the lines.

(6) Install the No. 5 bearing scavenge pump. (Refer to 72-5-6.)

THERMOCOUPLE AND HARNESS - MAINTENANCE PRACTICES

1. General. With the engine installed in the aircraft, maintenance is limited to the removal/installation of the forward lead and junction box. These may perform by normal practice.

2. Adjustment/Test. This procedure should be used in conjunction with trouble-shooting of the exhaust gas temperature indicating system (Refer to 72-0, Trouble-Shooting). It should be used only as a guide so as to determine if each thermocouple is functioning properly.

   A. Start the engine and accelerate to idle speed.

   B. Disconnect the thermocouple lead from the junction-box.

   C. Check the continuity of each of the thermocouples as follows:

      NOTE: The continuity of the thermocouple lead should be checked and proven good prior to this check.

      (1) Using a Jetcal Analyzer (BH112J-28T2, B&H Instrument Co., 1009 Norwood, Ft. Worth 7, Texas, or equivalent) connect the negative lead to the "A" terminal and the positive lead to each of the other terminals in succession.

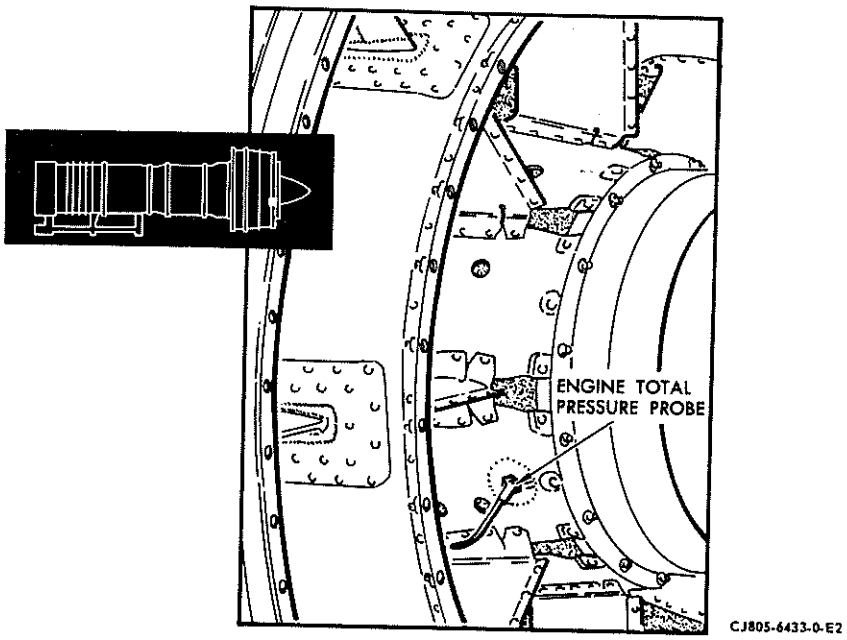
      (2) Check the meter as the positive lead is connected to each terminal. There must be a positive deflection of the meter.

   D. Connect the thermocouple lead to the junction-box.

   E. Shut-down the engine.

ENGINE TOTAL PRESSURE PROBE - MAINTENANCE PRACTICES

1. General. The maintenance of the pressure probe consist of removal/installation, inspection/check, cleaning and approved repair.



Removal/Installation of Engine Pressure Probe
Figure 201

2. Removal/Installation. (See figure 201.)

A. Removal

(1) Cut the lockwire and back-off the connector nut.

(2) Pull the probe and gasket from the fan rear frame.

B. Installation

(1) Place the gasket in the boss on the fan rear frame.

(2) Place the probe in the boss so the aligning pin on the probe is aligned with the boss.

(3) Secure the probe by tightening the connector nut and lockwiring.

3. Inspection/Check.

A. Check probe visually for damage. No dents or cracks allowable.

B. Check probe for position. Should be facing straight forward.

C. Check probe for clogged passage by removing the tube at the outer end of strut No. 6 on the fan rear frame. There should be no noticeable restriction.

NOTE: Only required if clogging is suspected.

4. Cleaning. If the probe is clogged it can be cleaned by passing a cleaning wire through it or using air pressure.

5. Approved Repair.

A. If probe is dented or cracked replace the probe.

B. If probe is bent out of position it may be straighten providing it doesn't crack.

C. If probe is clogged clean per paragraph 4.

Maintenance Practices 201
Adjustment/Test 201
Inspection/Check 205

78-1 THRUST REVERSER COMPONENTS

Maintenance Practices 201
Servicing 201
Removal/Installation 201

78-1-1 Blocker and Blocker Lip Assembly

Maintenance Practices 201
Removal/Installation 201
Inspection/Check 202
Approved Repair 205

78-1-2 Upper Support Beam and Lower Beam

Maintenance Practices 201
Removal/Installation 201
Inspection/Check 202
Approved Repair 203

78-1-3 Stowing Latch Assembly

Maintenance Practices 201
Inspection/Check 201
Approved Repair 201

78-2 COLLECTOR COMPONENTS

Maintenance Practices 201
Adjustment/Test 201
Inspection/Checks 203
Approved Repairs 204

78-3 THRUST REVERSER CONTROL SYSTEM

Maintenance Practices 201
Servicing 201
Inspection/Check 201
Approved Repair 201

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	Description and Operation	1
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	Removal/Installation	201
78-3-2	Thrust Reverser Filter	
	Description and Operation	1
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	Servicing	201
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78-3-3	Thrust Reverser Selector Valve	
	Description and Operation	1
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	Removal/Installation	201
78-3-4	Thrust Reverser Interlock Valve	
	Description and Operation	1
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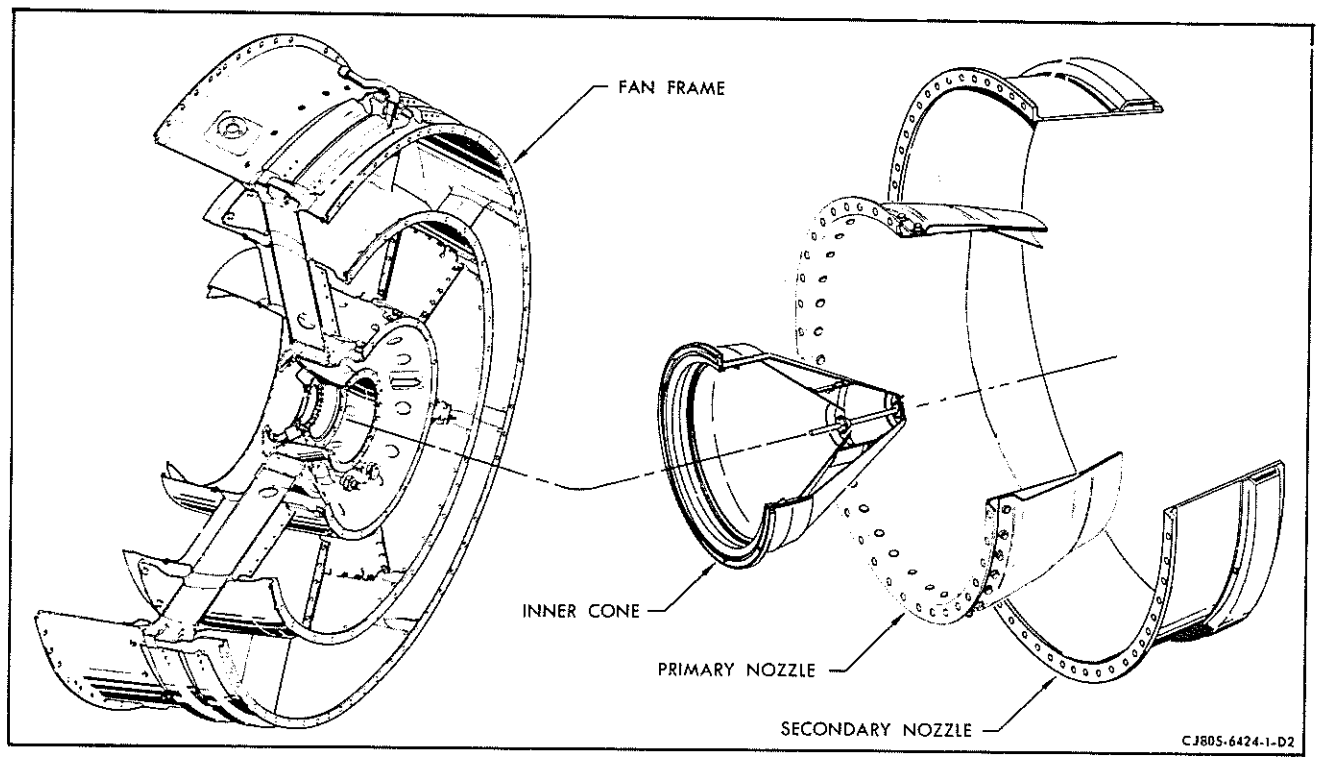
	Removal/Installation	201
78-3-5	Thrust Reverser Speed-Metering Valves	
	Description and Operation	1
	Maintenance Practices	201
	Removal/Installation	201
78-3-6	Blocker Actuators	
	Description and Operation	1
	Maintenance Practices	201

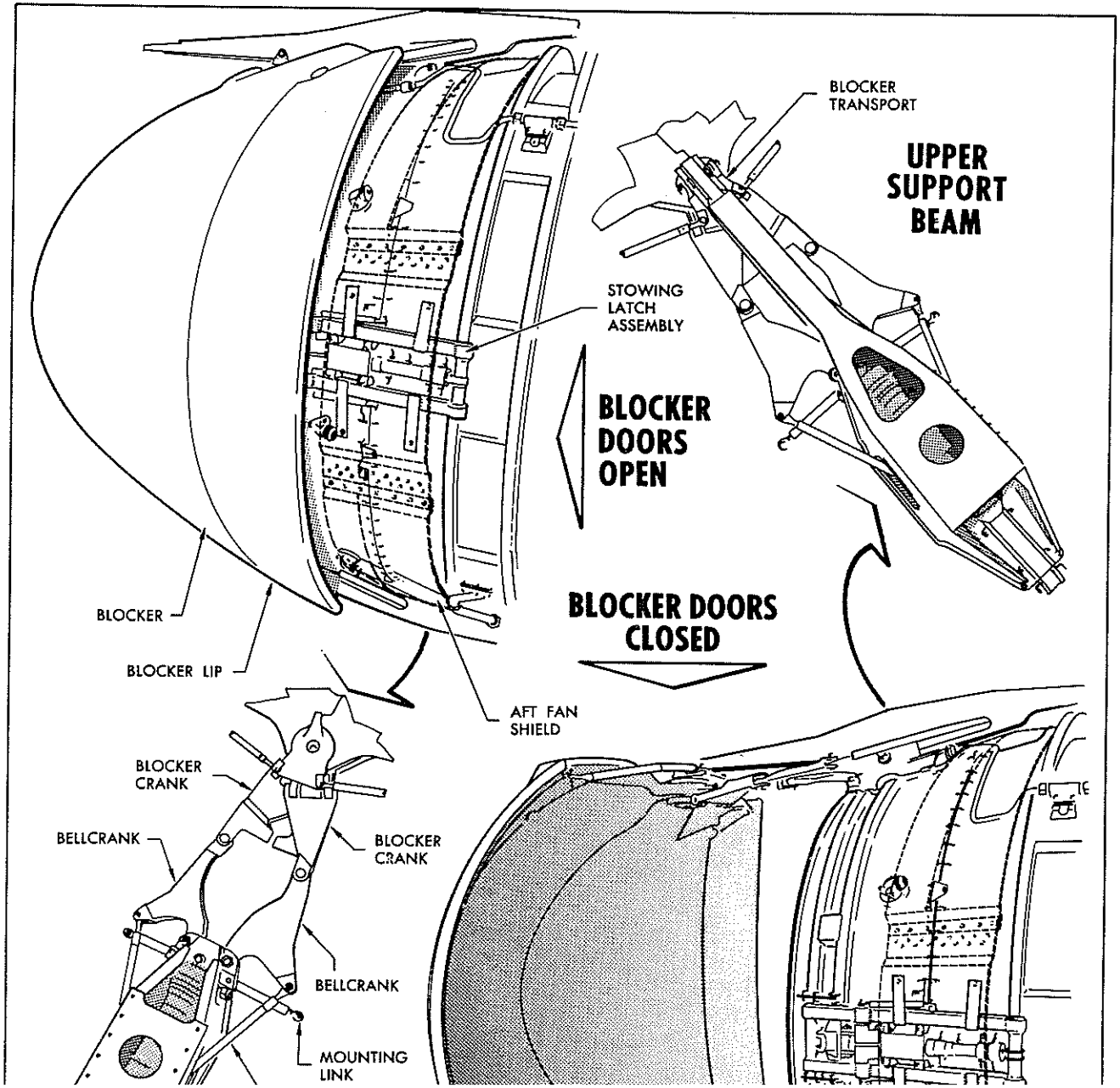
to give maximum thrust in either the forward or reverse direction. The direction of thrust is a function of the thrust reverser control system responding to the pilot's selection of forward or reverse thrust. For the purpose of describing the components, the exhaust section is divided into collector components, thrust reverser components, and thrust reverser control system components.

2. Exhaust Section Components.

A. Collector Components. The collector components (see figure 1) are bolted to the turbine and fan frame assembly. The inner cone is bolted to the inner flange, the primary nozzle to the middle flange and the secondary nozzle to the outer flange.



Collector Components
Figure 1


BLOCKER TRANSPORT
UPPER SUPPORT BEAM
STOWING LATCH ASSEMBLY
BLOCKER DOORS OPEN
BLOCKER DOORS CLOSED
BLOCKER
BLOCKER LIP
AFT FAN SHIELD
BLOCKER CRANK
BELLCRANK
BLOCKER CRANK
BELLCRANK
MOUNTING LINK

blockers. The stowing latch assemblies lock the blockers in the stowed position. The thrust reverser assembly is joined to the engine by support beams. The support beams are attached to the reinforcing hat sections at the top and bottom of the fan frame assembly.

C. Operation. Gases from the turbine and fan frame assembly center the exhaust section where they are transformed from an annular cross-section to a circular cross-section that has the proper area to produce maximum thrust. The transformation of the main engine exhaust gas from annular to circular cross-section occurs in the primary nozzle. The fan exhaust air is discharged through an annular passage formed by the outer skin of the primary nozzle and the inner skin of the secondary nozzle. The fan exhaust air mixes with the turbine main engine exhaust at the exit area of the primary nozzle.

The direction of the engine thrust is a function of the target-type thrust reverser which is attached to the turbine and fan frame assembly. The reverser contains 2 blockers that fair into the pod at the forward parting line on the sides when stowed. When the blockers are in the reverse thrust position, they redirect the engine exhaust gas to a generally sideward and forward direction.

On a later thrust reverser system a section of the aircraft pod, a translating cone, is connected to the thrust reverser blocker doors. When the doors are in the stowed position the translating cone covers the thrust reverser section. When the doors are moved into the reverse position the translating cone is moved to the rear, by a link between the door and the cone, and thereby exposes the reverser section.

3. Thrust Reverser Control System. The thrust reverser control system is a recirculating oil system which holds the blockers in the stowed or reverse position.

A. Components. The system components consist of a filter, restrictor, selector valve, interlock valve, latch actuators, blocker actuators, metering valve, check valve, and a pump. The purpose and location of the components are listed in the following table:

Components	Purpose	Location
Thrust reverser pump	To provide high pressure oil to the reverser and latch actuators.	7 o'clock position on the rear face of the rear gearbox.

Components	Purpose	Location
Thrust reverser filter	Filters the oil discharged from the pump to prevent contaminates from entering the reverser system.	7:30 o'clock position near the center of the rear compressor stator casing.
Relief valve	To bypass oil in case of restrictions in system.	Attached to outlet of filter.
Selector valve	In response to throttle position, oil is routed through the system which results in stowing or closing the blockers.	On the torque box attached to the main fuel control mounted on the forward side of the rear gearbox.
Interlock valve	To provide oil at pump discharge pressure to the blocker actuators and latch actuators or to vent the oil from the actuators to the oil tank.	7 o'clock position to the rear of the thrust reverser pump mounted on the rear face of rear gearbox.
Restrictor	To aid VSRM operation when reverser is in stowed position.	Actuator outlet of the interlock valve.
Metering check valve	To retard the speed at which the blockers come together when going into reverse thrust position.	7 o'clock position under the aft fan shield.
Relief check valve	To permit lower pressure when in reverse thrust position.	7 o'clock position under the aft fan shield.

Figure 3. Deleted.

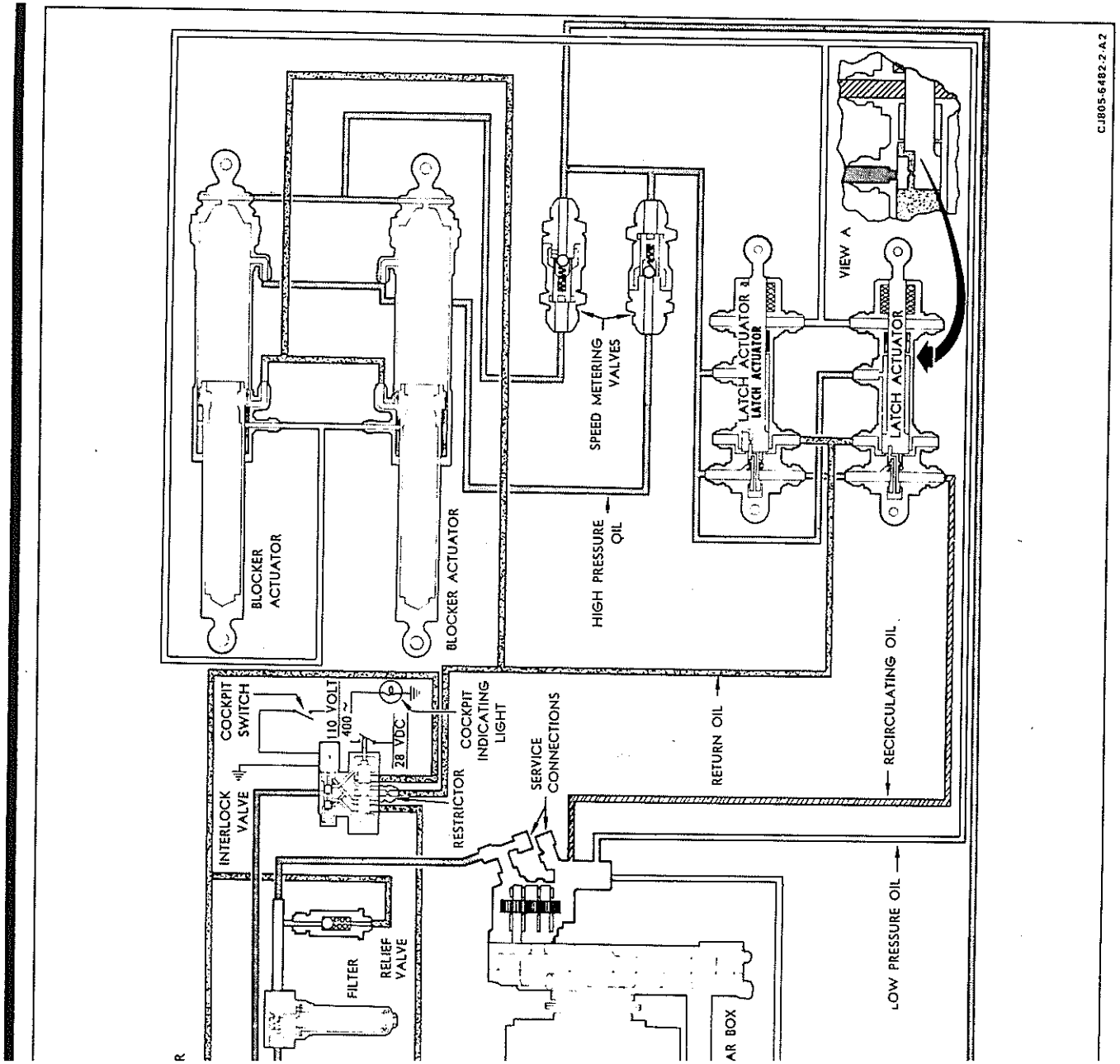
The control system schematic (figure 4) is shown in the forward thrust condition. Oil is gravity fed from the CSD section of the oil tank to the thrust reverser pump. The pump increases the pressure and discharges oil through an anti-static leak-check valve to the thrust reverser filter. Filtered oil is routed to the selectro valve and the servo piston in the interlock valve. The selector valve is mechanically connected to the air-frame supplied throttle cam on the fuel control. With the throttle in the forward thrust range, the selector valve routes oil to the metering valve. Oil from the metering valve flows to the rod end of the latch actuators and through an orifice and check valve to the head ends of the blocker actuators. The actuators hold and lock the blockers in the stowed position.

When the latch actuators are in the latched position the actuator piston opens the dump valve in the actuators. Oil flowing through the dump valve is routed to the inlet of the pump. During forward thrust conditions the interlock valve solenoid is de-energized.

To move the blockers to the reverse thrust position, the pilot lever is moved to the reverse thrust position. Moving the pilot lever to the reverse position energizes the interlock valve solenoid. The push-type solenoid moves the interlock valve pilot piston so that the piston routes oil at pump discharge pressure to the opposite end of the interlock valve power piston.

The pilot lever, in reverse position, also positions the selector valve to supply oil to the interlock valve power piston. The oil flows through the piston and restrictor to the head end of the latch actuators. The restrictor insures sufficient pressure to operate the VSRM (see 73-0). Since the blockers are still latched, they will not move until the latch actuators move toward the unlatch position. When high pressure on the head end of the latch actuator moves the latch piston to the right, the dump valve spring and the high pressure, working on the back of the valve through the passage in the center of the valve stem, moves the dump valve to the right shutting off the flow through the pump return line.

After the latch actuators have moved enough to unlatch the blockers the pistons in the blocker actuators begin to move to the reverse thrust


CJ805-6482-2-A2
BLOCKER ACTUATOR
BLOCKER ACTUATOR
SPEED METERING VALVES
HIGH PRESSURE OIL
LATCH ACTUATOR
LATCH ACTUATOR
VIEW A
COCKPIT SWITCH
110 VOLT 400 ~
28 VDC
COCKPIT INDICATING LIGHT
SERVICE CONNECTIONS
RETURN OIL
RECIRCULATING OIL
INTERLOCK VALVE
RESTRICTOR
FILTER
RELIEF VALVE
LOW PRESSURE OIL
GEAR BOX

the blockers. After the actuator piston passes the bypass port, system pressure is relieved through the check valve.

When forward thrust is required, the pilot lever is moved to the forward thrust position which de-energizes the interlock valve solenoid and moves the selector valve to the forward thrust position. This action routes high-pressure oil from the selector valve through the metering valve to the head end of the blocker actuators, moving the blocker doors to the forward thrust position. During movement of the blockers, the latch actuator pistons do not move, since the rod-end port is covered as shown in insert A, figure 4. When the blockers have reached the stowed position, the latch on the blocker contacts the catch and pushes the latch actuator piston. This action uncovers the rod-end port, porting high-pressure fluid to the rod-end of the piston. When the piston has reached the latched position, it contacts the dump valve, pushes the dump valve to the left and relieves the pressure in the system to the pump inlet.

The system contains 2 service connections: one downstream of the pump and one at the return oil inlet of the pump. These ports may be used to check system operation using a separate hydraulic pump.

2. Deleted.

3. Adjustment/Tests. There are 2 methods of testing (checking out) the thrust reverser actuating system. One method with the engine running is covered in Chapter 71, Adjustment/Test. The second method, which follows, is a static check procedure which may be used to trouble-shoot and check for proper installation of a replaced component.

NOTE: The reverser must have the translating cone disconnected from the reverser door and pushed aft to a position allowing free and complete movement of the doors to the reverse thrust position.

A. Connect the hydraulic pump, 2C4007, to the system as follows:

(1) Remove the cap from the service connection tee at the outlet of the thrust reverser pump.

(2) Connect the supply line from the hydraulic pump to the service connection. This is the pump outlet line.

(3) Remove the cap from service connection in the line between thrust reverser pump and the outlet of the oil tank.

(4) Connect return line of the hydraulic pump to the service connection. This is the pump inlet.

B. Actuate the pump.

C. Cycle the thrust reverser system as follows:

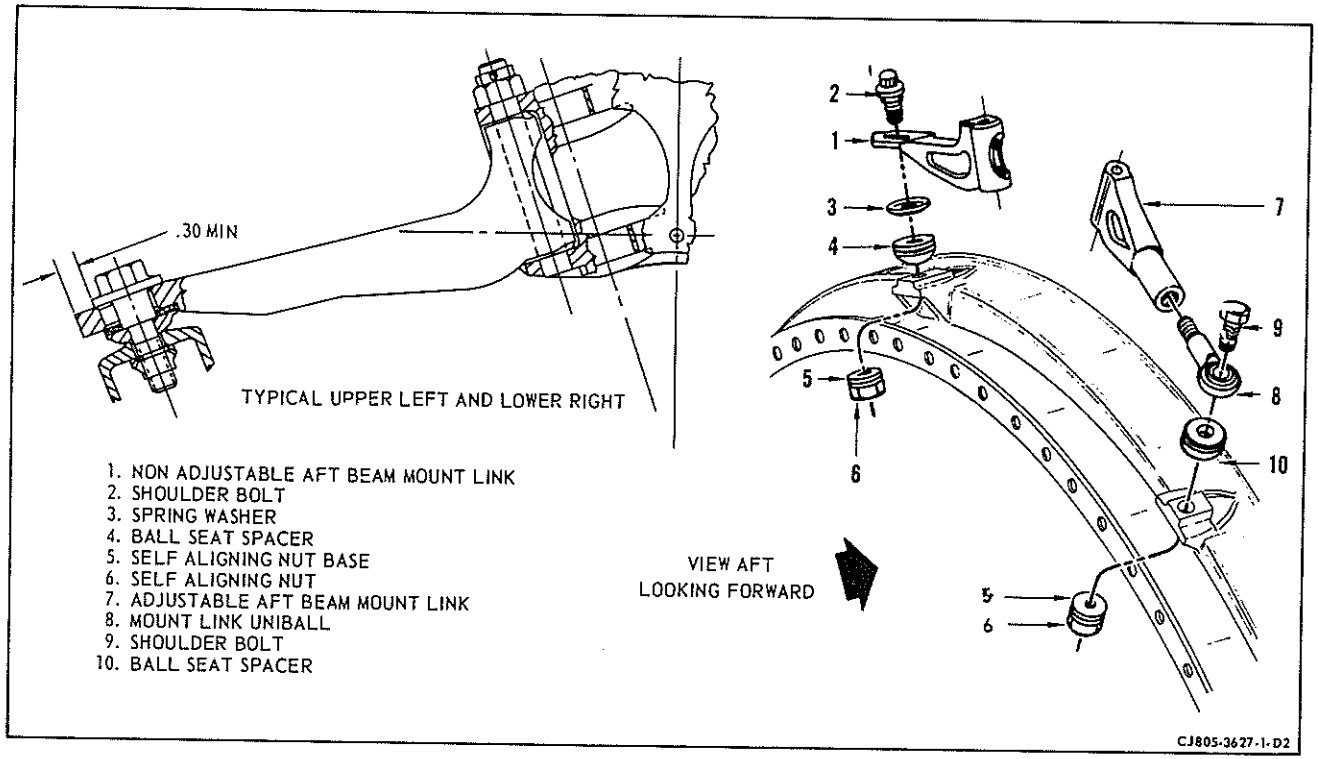
NOTE: This procedure makes use of the aircraft throttle linkage.

(1) Check throttle to see that it is in the idle position.

(2) Pull the thrust reverser lever all the way back.

NOTE: This will actuate the system and place the blockers in the reverse thrust position.

(3) Push the thrust reverser lever all the way in.



Aft Beam Mount Links - Assembly
Figure 201

NOTE: This will actuate the system and place the blockers in the stowed position.

D. Rigging procedure.

(1) With zero system pressure and blocker doors in stowed position, check for roller contact on upper beam. Adjust mount links per paragraph E.(1) and (2).

NOTE: Length of rods with Klincher nuts should not exceed 18.25 inches from center to center of bolt holes.

(b) Stirrups must not contact stirrup stops or latch catches. Adjust per paragraph G.

NOTE: The doors should be loose enough to be moved freely fore and aft with one hand.

(c) Check latch actuators for full latching. (If blucket shield covers latching area, look through hole in shield.) Actuator rod should be all the way in the cylinder, only the threads visible.

(5) With blocker doors in stowed position, zero system pressure, shim stop bolts to obtain 0.000-0.030 inch clearance with blocker bearings.

(6) Move blocker doors to reverse position, zero system pressure and check for contact between door bumpers and blocker crankdogs. Gap at outer end of door bumpers must not exceed gap at blocker crankdogs by more than 0.060 inch. Add or remove shims to door bumper to minimize gap.

NOTE: The blocker doors may not travel to the full reverse position due to the bypass system of the actuators. In the event this happens the doors may be moved by hand to the full reverse position. Doors should be moved until door bumpers touch at inner end or until the blocker crankdogs touch.

(7) Cycle reverser 6 times and check for proper operation and oil leakage. Leave doors in reverse position and re-check actuator rod adjustment per step (3).

(8) Move blocker doors to stowed position and remove hydraulic pump from the system.

(9) Reconnect the translating cone to the reverser door.

(10) Check oil level in CSD tank per servicing instructions in Section 72-5-0.

E. Mount link adjustment. (Doors in reverse position, zero system pressure.)

NOTE: Some method of supporting the weight of the doors should be used while making this adjustment.

(1) Left roller not contacting - lengthen both upper right and lower left mount links equally or lengthen lower left only.

(2) Right roller not contacting - shorten both upper right and lower left mount links equally or shorten lower left only.

(3) Upper left under minimum - lengthen upper right and shorten lower left mount links equally.

(4) Lower right under minimum - lengthen lower left and shorten upper right mount links equally.

(5) If steps (3) or (4) are performed, re-check for roller contact per D.(1).

F. Lip link adjustment. (Doors in reverse position, zero system pressure.)

(1) Remove lower lip links.

(2) Adjust upper lip links as follows:

(a) To move lips forward - shorten upper lip links.

(b) To move lips aft - lengthen upper lip links.

NOTE: If only the nacelle to lip clearance is out, adding or removing shims to door stop bolt will correct this.

(3) Move doors to stowed position and re-check clearances.

(4) Move doors to reverse position.

NOTE: As this adjustment will mis-align the bolt holes approximately 0.050 inch per turn of eye bolt, it will be necessary to move the lip so the bolt holes in lip clevis will align with lip link.

G. Stirrup adjustment. (Doors in reverse position, zero system pressure.)

(1) Remove stirrup bolts and loosen switch bracket bolts.

(2) Lift switch bracket legs out of stirrup.

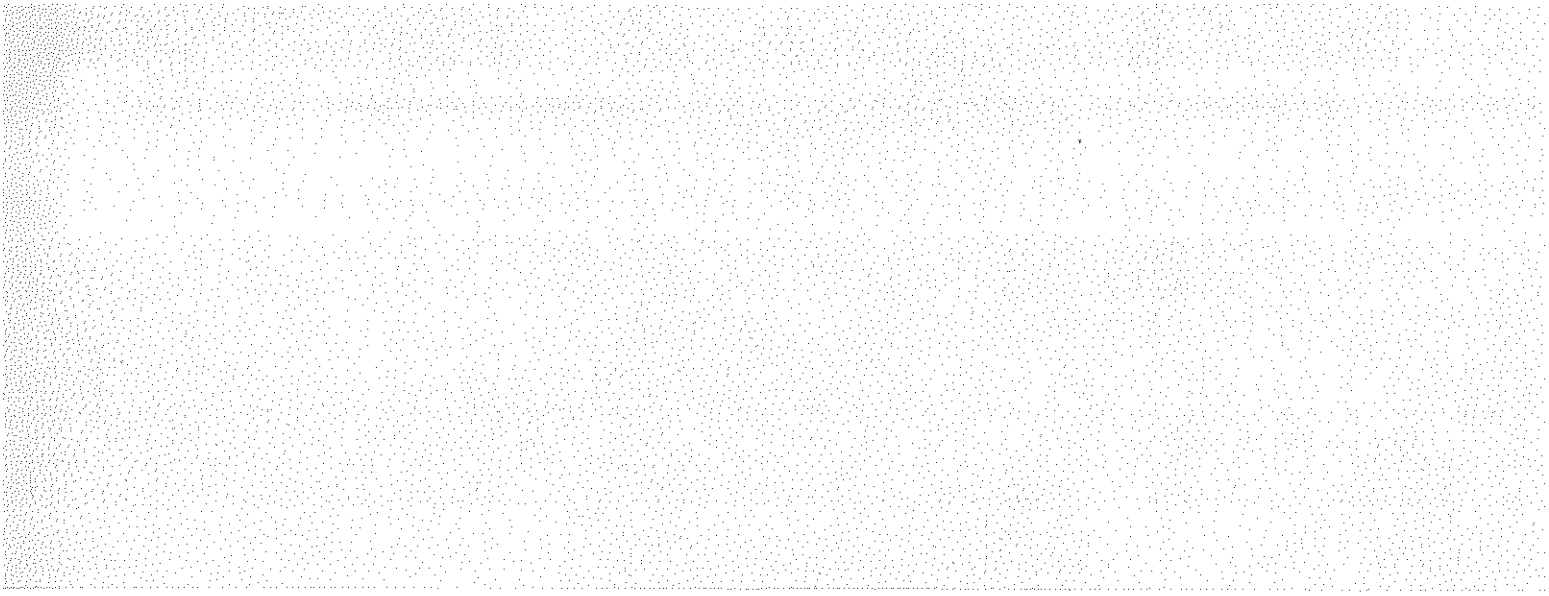
(3) Slide stirrup out of the tongue serrations and re-install by changing the desired number of serrations. One serration will move the stirrup approximately 7/64 inch.

NOTE: If the stirrup cannot be adjusted because the end of adjustment has been reached; move the stirrup on the other door the desired number of serrations in the opposite direction to achieve the same result.

(4) Assemble switch bracket legs and stirrups bolts. Torque bolts.

(5) Re-cehck adjustment.

4. Inspection/Check. Visually inspect/check all components for cracks, accessories and tubing for leaks. Serviceable limits on components are defined in the sections on the thrust reverser and collector components.



engine mounted in the airframe.

2. Servicing.

CAUTION: DO NOT MIX DIFFERENT TYPES OF GREASES TOGETHER. COMPLETELY REMOVE OLD GREASE IF DIFFERENT TYPE OF GREASE IS TO BE USED AS THE GREASES MAY NOT BE COMPATIBLE.

A. Grease fittings on thrust reverser blocker bearings, blocker lips and stowing latch cranks must be serviced with Nebula 1 (also known as EPI) manufactured by ESSO Standard, or equivalent, on a daily basis.

B. Lubricate the actuator slider tracks, the stowing latch slider tracks, and the upper support beam track with Molykote M-77, (Alpha Corp., Greenwich, Conn.) or Dry Film Spray, DGF 123 (Miracle Products Corp., Cleveland 9, Ohio) or equivalent, on a daily basis.

3. Removal/Installation.

NOTE: After replacement of any component, recheck rigging per 78-0, paragraph 3.

A. Removal of Blocker and Blocker Lip Assembly.

(1) Remove 4 shoulder bolts and castle nuts securing the blocker cranks to the bellcranks.

(2) Separate the blocker and blocker lip assembly by guiding the blocker transport off the track of the upper support beam.

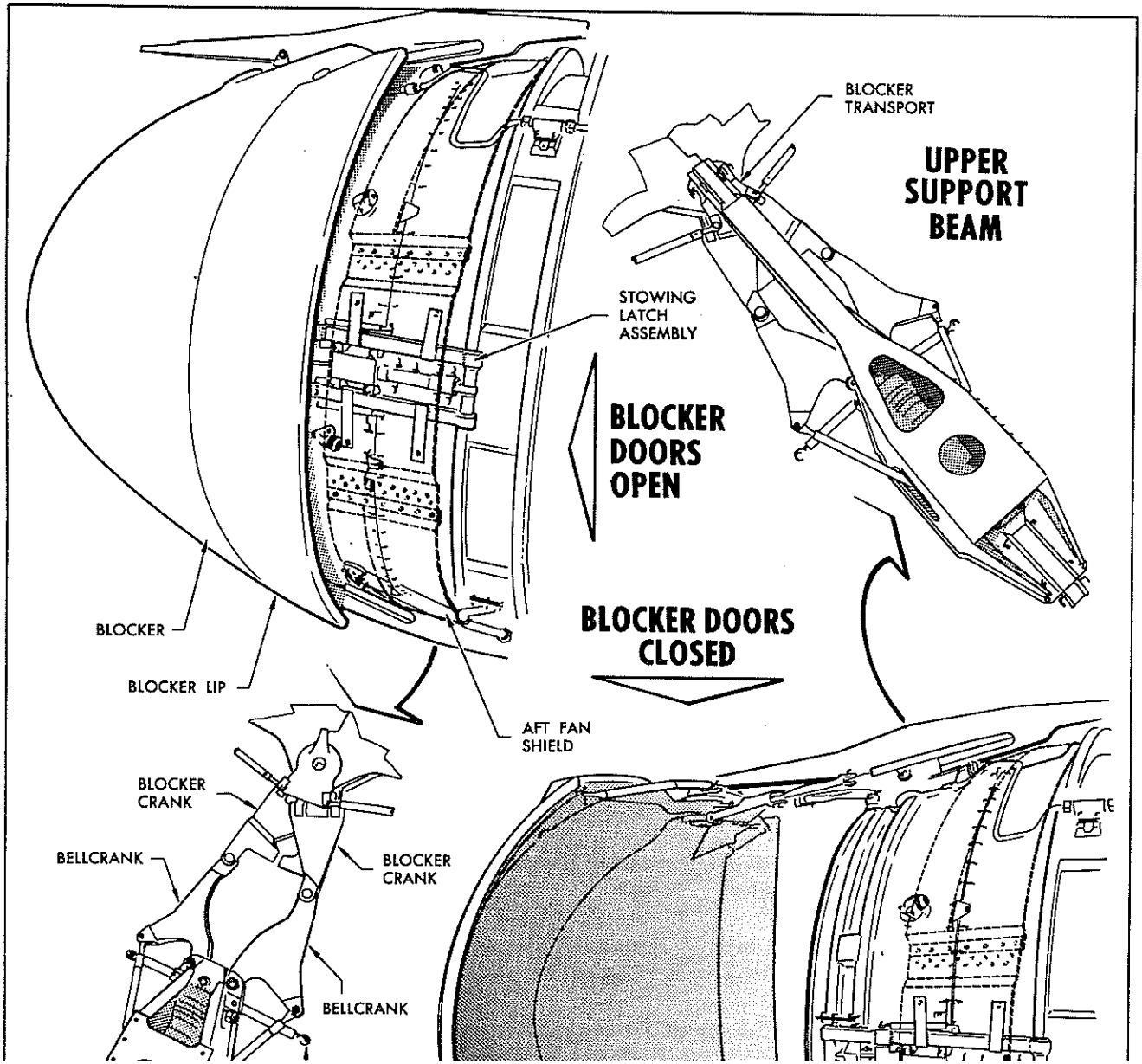
B. Installation of Blocker and Blocker Lip Assembly.

(1) Guide the blocker transport on the track in the upper support beam.

(2) Align the holes in the blocker cranks and bellcranks and insert 4 shoulder bolts. Secure shoulder bolts with castle nuts. Torque nuts to 10 lb-in. maximum and back off, if necessary, to insert cotterpin.

C. Removal of Upper Support Beam and Lower Beam.

NOTE: In order to remove the upper support beam and/or lower beam, the blocker and blocker lip assembly must be removed. Refer to paragraph A.


BLOCKER TRANSPORT
UPPER SUPPORT BEAM
STOWING LATCH ASSEMBLY
BLOCKER DOORS OPEN
BLOCKER DOORS CLOSED
BLOCKER
BLOCKER LIP
AFT FAN SHIELD
BLOCKER CRANK
BELLCRANK
BLOCKER CRANK
BELLCRANK

(4) Remove lower beam.

(5) Remove 6 bolts that secure the forward beam mount to the upper support beam.

(6) Remove the upper support beam.

D. Installation of Upper Support Beam and Lower Beam.

(1) Place the upper support beam on the beam forward mount and secure with 6 bolts.

(2) Install 4 bolts to secure the aft fan shield to the upper support beam.

(3) Deleted.

(4) Install the shoulder bolts in the aft links and fan frame mounting lugs.

NOTE: Frame pad thickness varies resulting in the use of different length bolts. Check the bolt for proper thread engagement and clearance with frame.

(5) Connect lines to the actuators in the upper support beam and lower beam.

E. Removal of Stowing Latch Assembly.

(1) Disconnect the lines to the stowing latch actuators.

NOTE: A bracket riveted to the blucket shield and located about mid-point in the stowing latch assembly, is attached to the assembly by 2 bolts. These bolts must be removed. The lines above the latch assembly also must be removed.

(2) Deleted.

(3) Remove the shoulder stud from the frame forward mount and 4 bolts securing the aft mounting brackets to the frame.

(4) Remove the stowing latch assembly.

F. Installation of Stowing Latch Assembly.

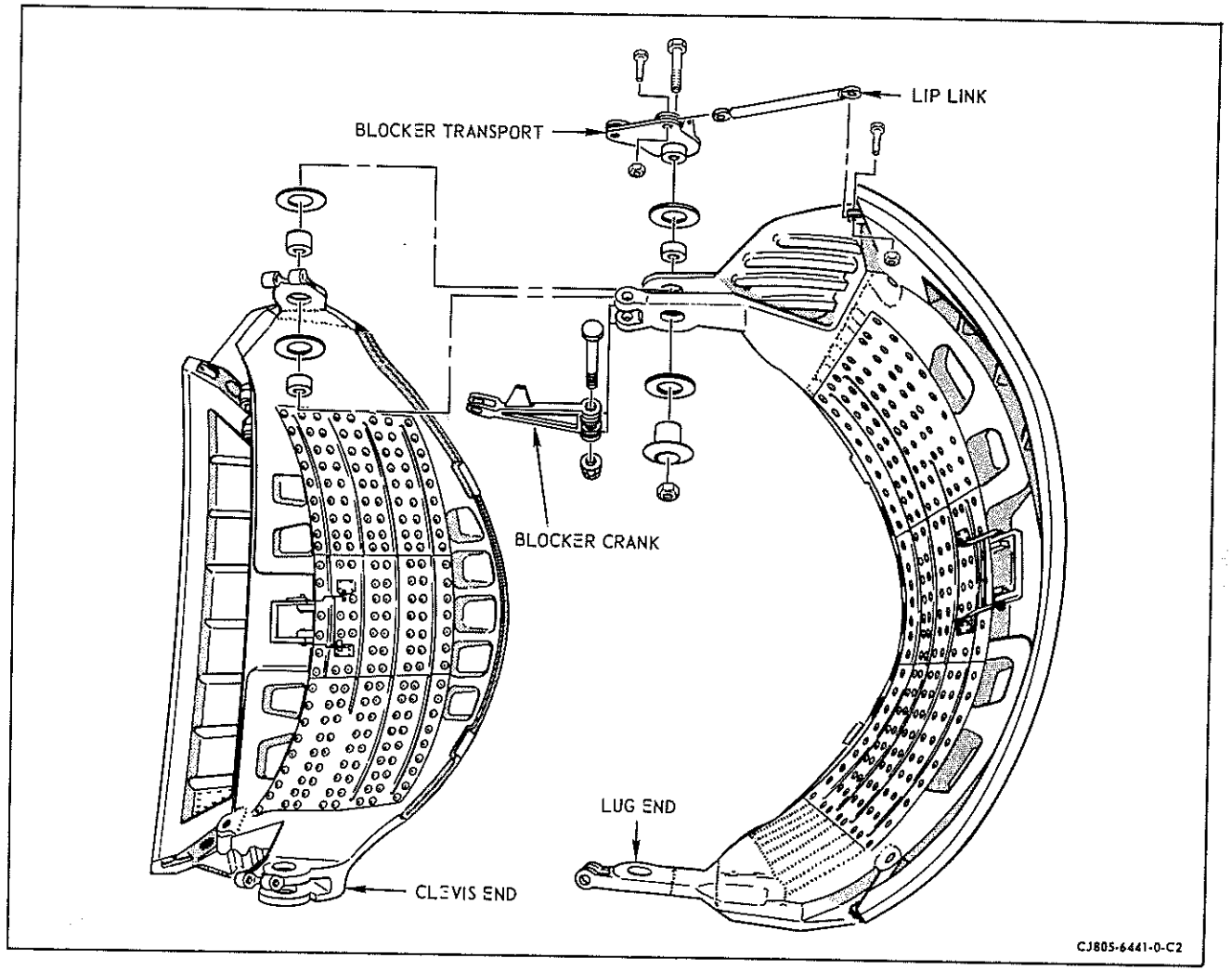
(1) Install the stowing latch assembly on the fan frame and secure the forward mount with a shoulder stud.

NOTE: Install 2 bolts to secure the latch frame to the forward shield. Reconnect lines above assembly.

(2) Connect the lines to the stowing latch actuators.

(3) Deleted.

2. Removal/Installation. (See figure 201.)



Blocker and Blocker Lip Assembly
Figure 201

A. Removal.

(1) Remove the bolts and nuts that secure the lip links to the blocker lip and the blocker transport, and the lip links that secure the blocker lip to the bearing plate.

(2) Remove the shank bolts that join the blocker cranks to the blockers.

(3) Remove the bolts and nuts that secure the blocker transport and bearing plate to the blocker and blocker lip assembly.

(4) Separate the bearing journals, bearing sleeves, blocker transport and bearing plates from the lug and clevis ends of the blockers. Separate the lug and clevis ends of the blockers.

B. Installation.

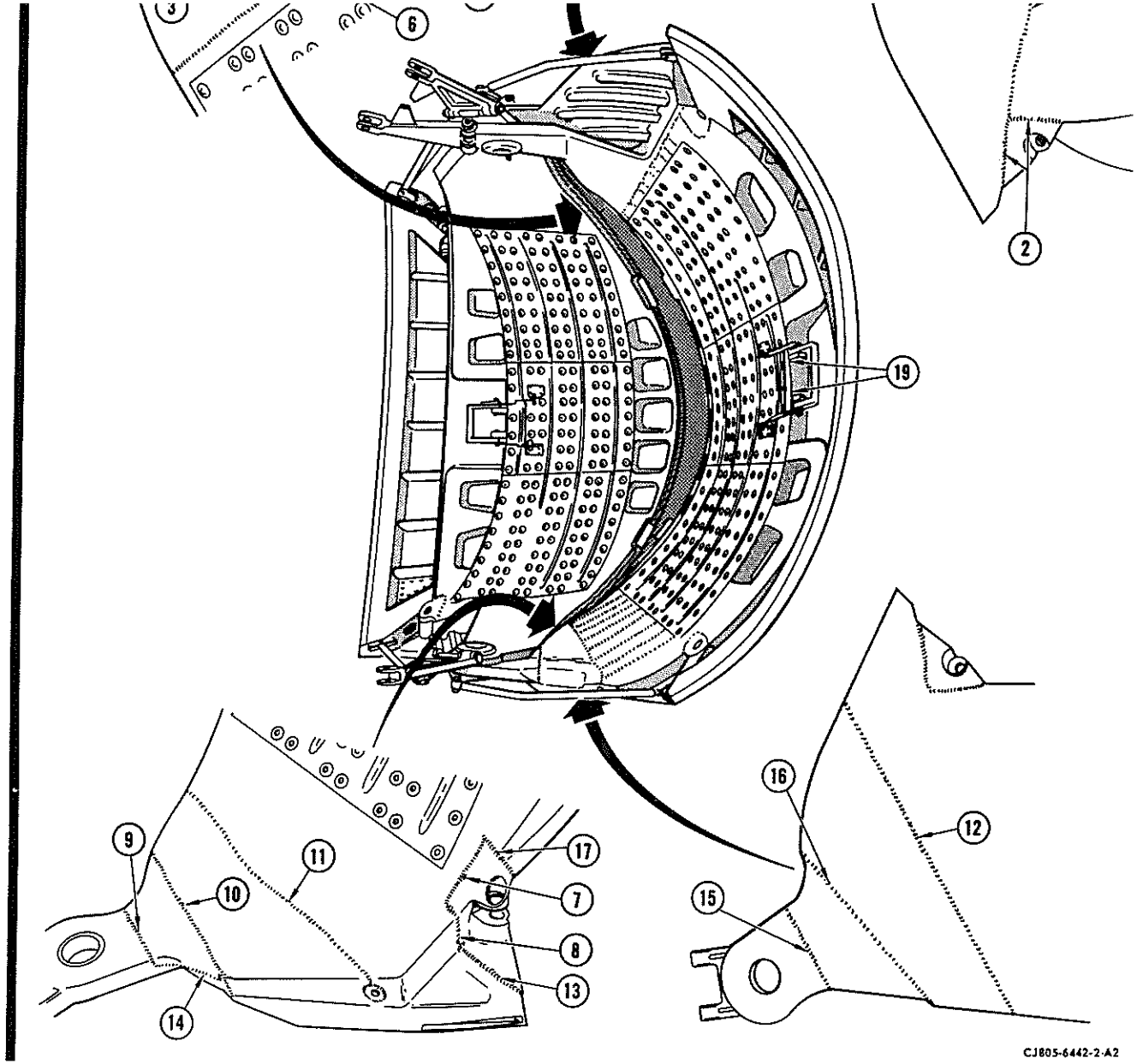
(1) Align the lug and clevis ends of the blockers for the assembly of the bearing journals, bearing sleeves blocker transport and bearing plate. Secure with bolts and nuts.

(2) Install the blocker crank on the blocker and secure with shank bolt, and nut. Torque castle nuts to 10 lb-in. maximum and back off, if necessary, to insert cotter pin.

(3) Install the lip link between the blocker lip and blocker transport and between the blocker lip and bearing plate. Secure with nuts and bolts.

3. Inspection/Check. Visually inspect the following listed areas.

Inspect/Check	Maximum Serviceable Limit	Remarks
A. Blockers for cracks:		
(1) Welds at external clevis side (1, figure 202)	One crack, 1/2 inch long in each weld	Repair per paragraph 4.
(2) Welds at external	A total crack length of 1 inch	Repair per paragraph



Blocker Inspection/Check
Figure 202

Inspect/Check	Maximum Serviceable Limit	Remarks
(4) Extending from rivet holes (4, figure 202)	One inch crack from each rivet hole	Repair per paragraph 4.
(5) Welds at inside of the clevis (5, figure 202)	One inch crack	Repair per paragraph 4.
(6) Welds at inside of the clevis (6, figure 202)	Two inch crack	Repair per paragraph 4.
(7) Welds at lip mount casting (7, figure 202)	A total crack length of 1 inch in each weld	Repair per paragraph 4.

ure 202)		
(10) Welds at the inside liner (10, figure 202)	One inch long	Weld per paragraph 4.
(11) Welds at the inside lug casting (11, figure 202)	3 cracks, with a total accumulative length not to exceed 1 inch	Weld per paragraph 4.
(12) Welds at the outside lug end (12, figure 202)	3 cracks, with a total accumulative length not to exceed 2 inches	Weld per paragraph 4.
(13) At weld 13, figure 202	One crack, one inch long	Weld per paragraph 4.
(14) At weld 14, figure 202 (forward and aft edge)	One crack, one inch long	Weld per paragraph 4.
(15) At weld 15, figure 202	Not serviceable	Weld per paragraph 4.
(16) At weld 16, figure 202	One crack, one inch long	Weld per paragraph 4.
(17) At weld 17, figure 202	One crack, 1/2 inch long	Weld per paragraph 4.
(18) At weld 18, figure 202	3 cracks, with a total accumulative length not to exceed 2 inches	Weld per paragraph 4.
(19) At weld 19, figure 202	Cracks in both welds not to exceed a total accumulative length of 1/2 inch	Weld per paragraph 4.

Inspect/Check	Maximum Serviceable Limit	Remarks
B. Loose or missing rivets:		
(1) Blocker	20 percent	Replace all missing or loose rivets if serviceable limit is exceeded
(2) Stirrup mount to the outer skin	4 loose or missing rivets	Replace all missing or loose rivets if serviceable limit is exceeded
C. Blocker lip welds for cracks	3/4 inch long in each weld	Repair per paragraph 4.
D. Blocker cranks for cracks	Not serviceable	Replace part.
E. Bearing journals for cracks	Not serviceable	Replace part.
F. Bearing plates for cracks	Not serviceable	Replace part.
G. Blocker transport for cracks	Not serviceable	Replace part.
H. Washers for cracks	Not serviceable	Replace part.
I. Lip links for cracks	One crack up to 1/2 inch long in longitudinal direction only in each link	Weld per Section 89-1-3 paragraph 8.
J. Movement between transport guides and upper beam track	0.125 inch	

(2) Torch Gas: Argon 10-15 cubic feet per hour; gas backing required.

(3) Filler Wire: AMS 5786 (Hastelloy W).

(4) Electrode: 1/16 inch diameter tungsten.

(5) Amperes: 30-60.

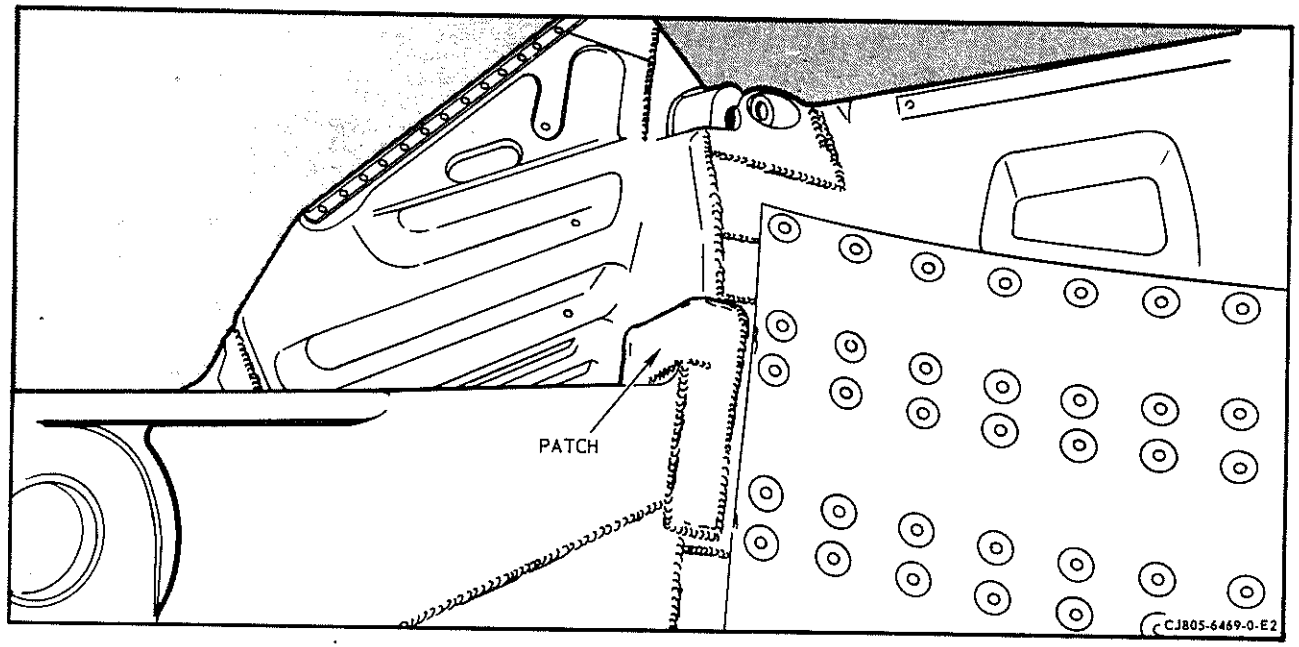
(6) Arc Starting: On copper strip if high frequency is not incorporated in welding machine.

NOTE: A remote control variable current device should be employed to control heat input. Arctrol, (Mullenback Electrical Mfg. Co., 2300 East 27 Street, Los Angeles, California) or equivalent.

(7) Spot-fluorescent-penetrant inspect.

C. Cracks in welds (5 and 6, figure 202) will be repaired as follows:

(1) Repair cracks per sub-paragraph A. and B.



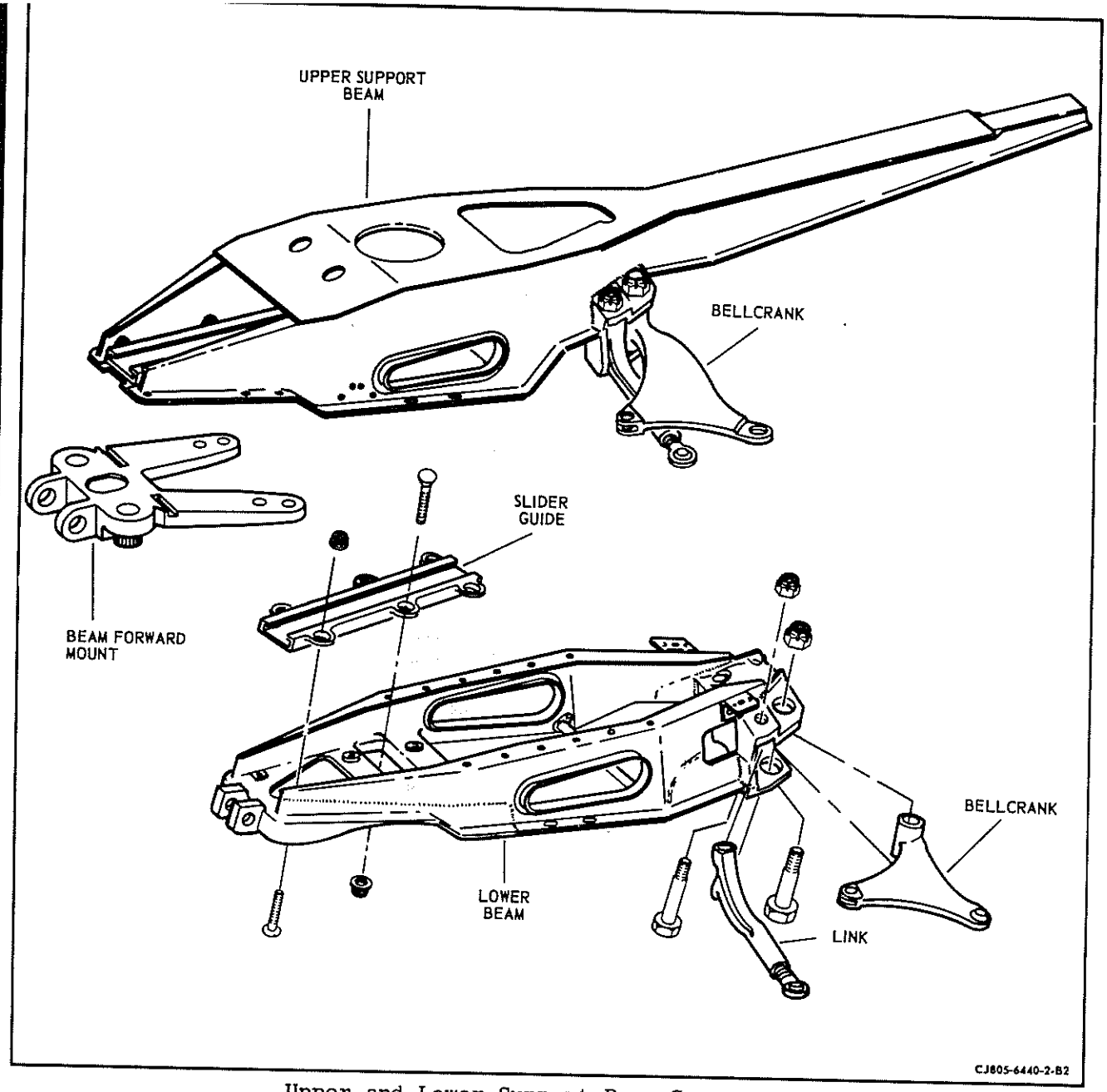
Patch Repair of Blocker
Figure 203

(2) Bench welds flush with parent metal.

(3) Install patch by forming to fit over weld repaired area. (See figure 203.)

(4) Fillet weld patch to blocker door. Fillet height not to exceed height of patch.

(5) Spot-fluorescent-penetrant inspect.



Upper and Lower Support Beam Components
Figure 201

NOTE: The following removal/installation procedures cover the remaining components attached to the beam after the actuator has been removed. It is the same for the upper support beam and lower beam.

A. Removal.

(1) Remove the bolts and nuts that secure the bellcranks to the beams. Remove bellcranks.

(2) Remove the hinge pins that secure the aft mount links to the beams. Remove the links.

(3) Remove the 6 bolts and nuts that secure the beam forward mount to the upper beam.

(4) Remove the bolts that secure the slider guides to the beams. Remove slider guides.

B. Installation.

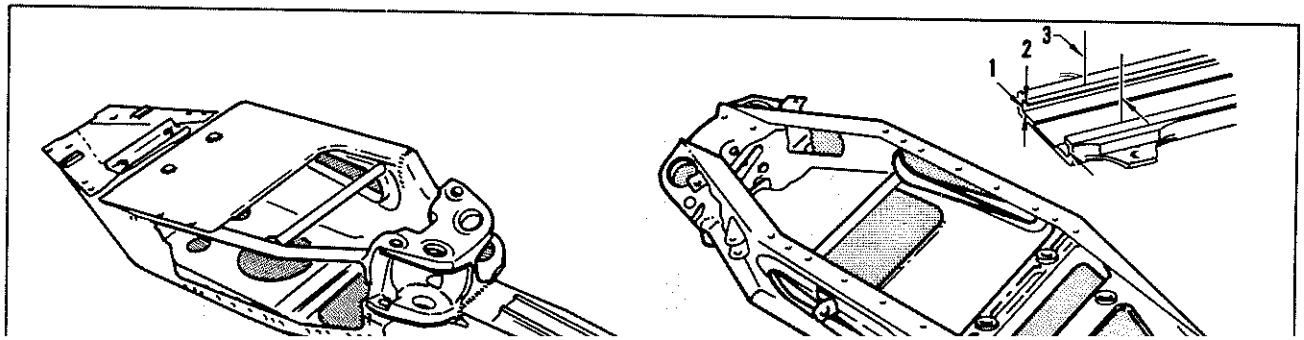
(1) Install slider guides in beams and secure with bolts.

(2) Install aft mount links on the beams and secure with hinge pins.

(3) Install bellcranks on the beams and secure with nuts and bolts.

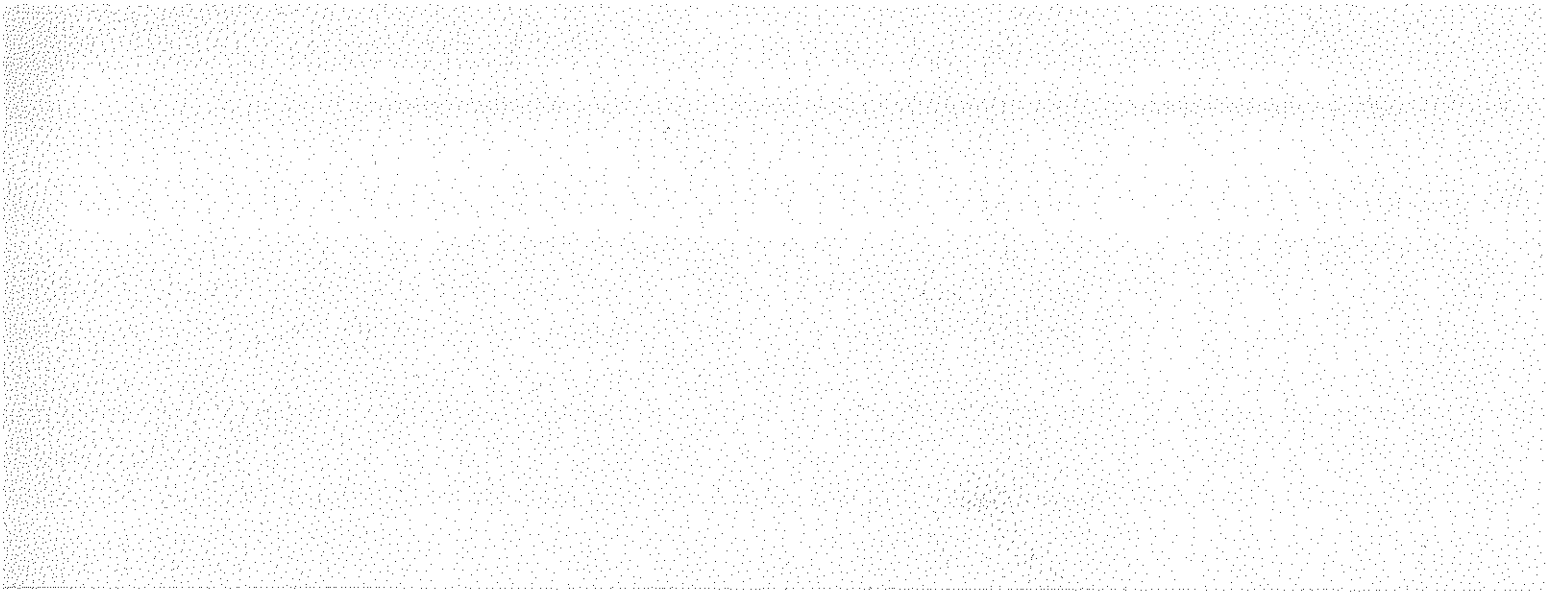
(4) Install the beam forward mount on upper beam. Secure with 6 bolts and nuts.

3. Inspection/Check. (See figure 202.)



B. Beam forward mount for cracks	Not serviceable	
C. Slider and slider guide for cracks	Not serviceable	
D. Slider guide for wear:		
(1) Track width (1, figure 202)	Not to exceed 1.849 inches	
(2) Track height (2, figure 202)	Not to exceed 0.170 inches	
(3) Rails width (3, figure 202)	Not to exceed 1.597 inches	
E. Slider for wear:		
(1) Runner height	A minimum of 0.145 inch	
(2) Runners for nitride surface (all sliding surfaces)	Nitride surface must be present	Check for nitride surface may be accomplished with a fine file.
F. Stop-bolts in the upper and lower beam for damage	Any number of nicks or dents provided cracks are not present	If the bolt is damaged, check for cracks using spot penetrant inspection per 89-1-8. Replace cracked bolts.

4. Approved Repairs. Refer to section 89-1-3 for weld repair procedure for 410 stainless steel and localize heat treatment of repair welds.



a bolt can be installed in the slider guide and thereby retain the doors.

2. Inspection/Check.

Inspect/Check	Maximum Serviceable Limit	Remarks
A. Frame for cracks	1/4 inch long	
B. Straps for cracks	1/2 inch long	
C. Components assembled on the frame for cracks	Not serviceable	
D. Axial movement of stowing latch frame to fan frame (with the bolts attaching the straps to the fan shield removed)	0.060 inch	
E. Stirrup stops for wear	Any amount of wear not exceeding 0.060 inch in depth	

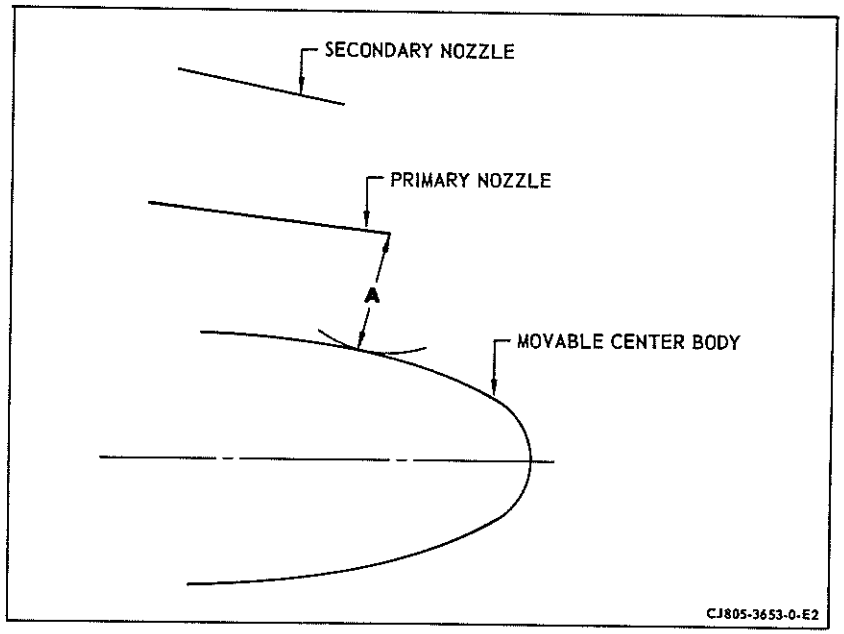
3. Approved Repairs. Replace the assembly and return to overhaul facility for repair.

2. Adjustment/Test. The only adjustment made is to an inner cone that is a replacement or has had the length changed. The slant-height dimensions given below are nominal values. If the engine has been adjusted for optimum performance and has been assigned a slant-height dimension, this dimension should be used in the place of the nominals given. Engine records should be consulted to determine if there is an assigned slant-height. The methods of setting slant-height are as follows:

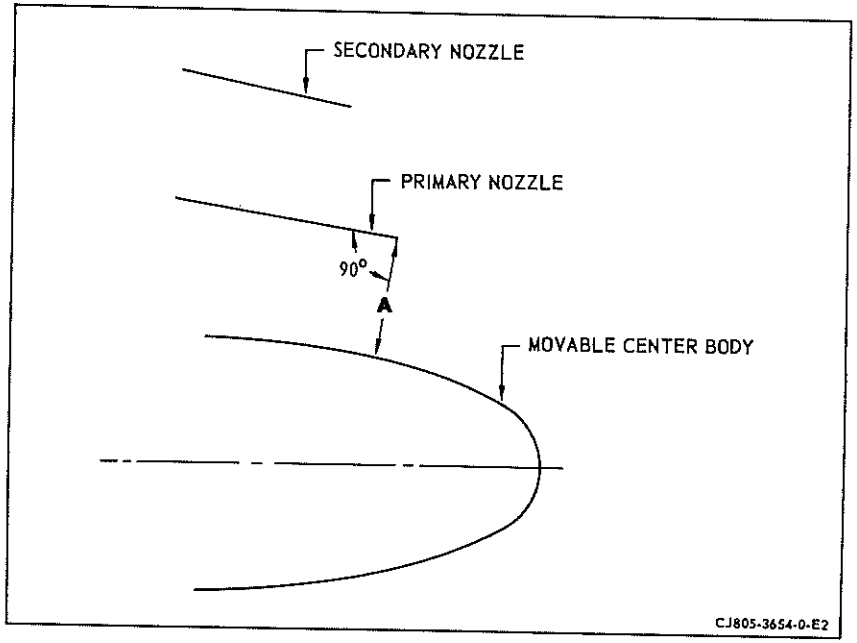
NOTE: The method of setting slant-height is different for the CJ805-23B than it is for the -23.

A. On the CJ805-23 engine, adjust the movable centerbody (inner cone) using tool 2C4496 to give a slant height "A" of 7.10 plus 0.03 or minus 0.03 inches as shown in figure 201. This slant height is measured by swinging an arc from the inner tip of the primary nozzle, tangent (and, hence, perpendicular) to the movable center body. The slant height dimension should be the arithmetic average of eight equally spaced measurements.

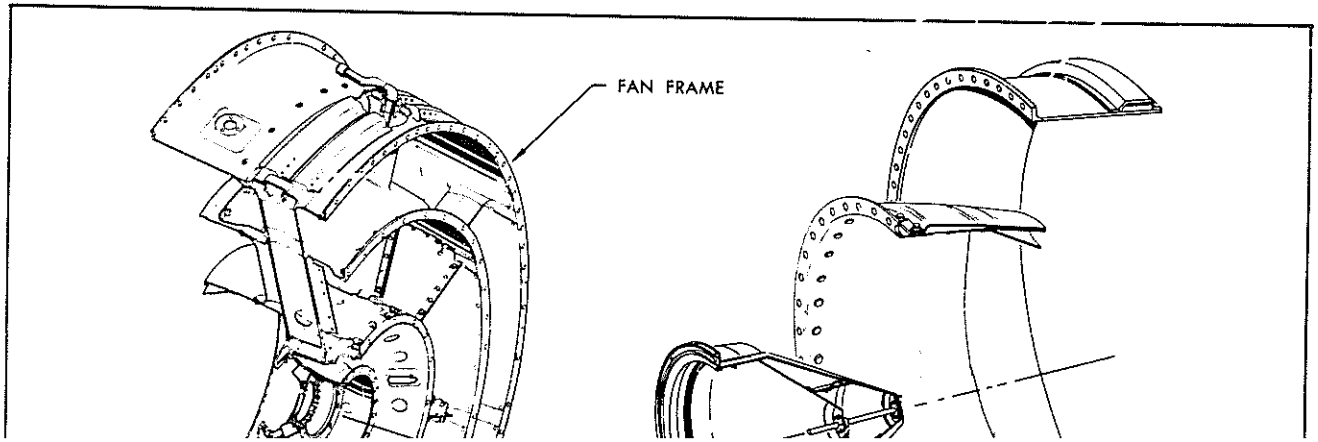
B. Deleted.



Adjustment Check of Inner Cone (-23 Engine)
Figure 201



Adjustment Check of Inner Cone (-23B Engine)
Figure 202



Inspect/Check	Maximum Serviceable Limit	Remarks
A. Inner cone for:		
(1) Cracks	Not serviceable	
(2) Nicks, dents and burned areas which have broken the skin	Not serviceable	
B. Primary nozzle		
(1) Cracks in the skin	One inch long	
(2) Radial cracks emanating outward from flange mounting bolt holes	One per hole	
(3) Nozzle flange radius for circumferential cracks	Not serviceable	
(4) Missing rivets	3 rivets may be missing provided there are 5 good rivets on each side of missing rivet	Missing rivets may be replaced with a size No. 2 round head bolt and locknut up to a maximum of 10 per nozzle.
C. Secondary nozzle		
(1) Cracks	Not serviceable	
(2) Hole in hat section (usually caused by blocker crank hinge bolt)	One hole, 1/4 inch in diameter	Ding hat section as required to remove interference.

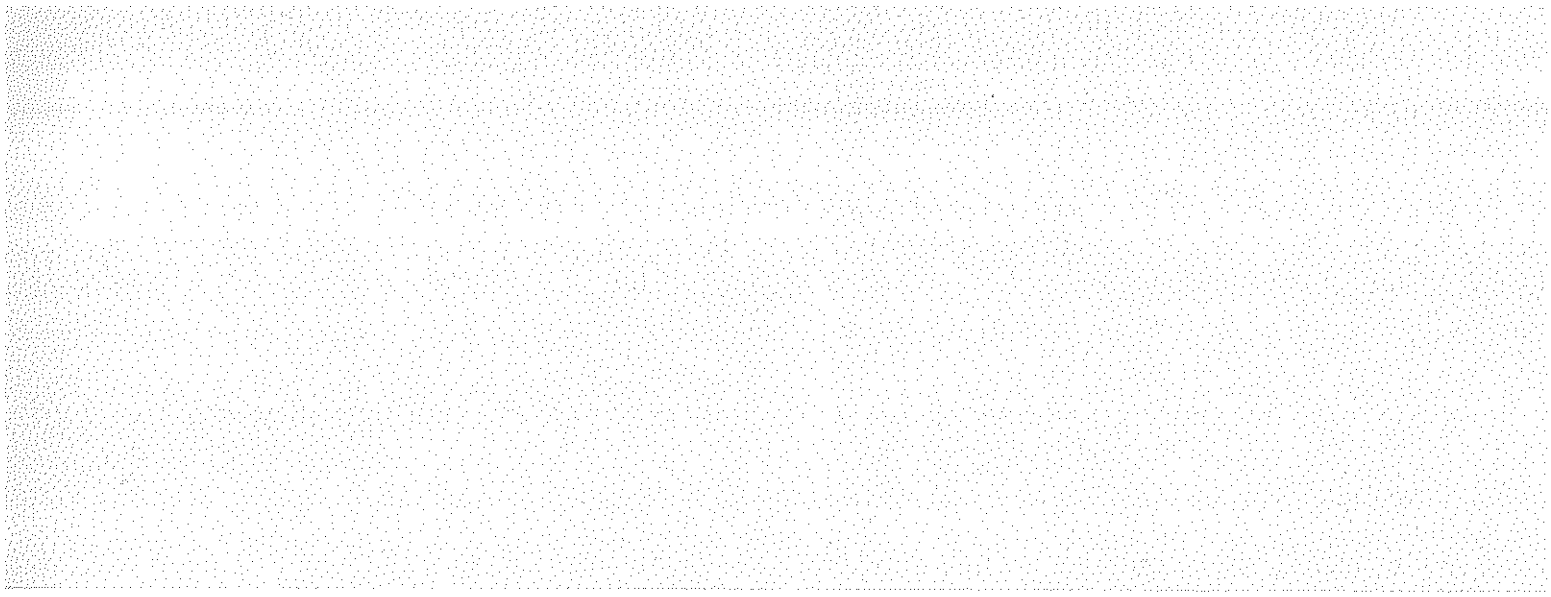
Inspect/Check	Maximum Serviceable Limit	Remarks
D. Fairing ring		
(1) Radial crack from the edge of the bolt hole to the ID of the ring (flange)	One per bolt hole	
(2) Circumferential crack around bolt hole	6 cracks, maximum length of 120 degrees measured at bolt head circumference. If 2 adjacent bolt holes have a typical crack then there must be 10 bolt holes between the 2 adjacent holes and the next cracked hole	

4. Approved Repairs. Replace all parts with approved replacement or serviceable part.

kinked hoses and bent, dented or damaged tubing.

4. Approved Repair. Replace any damaged or defective parts.

NOTE: If accessories are removed from the engine and placed in spare parts stock, they must be preserved per the instructions in 89-1-7.



B. This pump is of the gear type with pressure loaded bearings. It is designed to supply hydraulic pressure continuously, operating at speeds between 2280 and 4200 RPM at pressures from 0 to 3000 PSI. Rated capacity is 5.1 GPM at 2280 RPM and 3000 PSI pumping MIL-L-7808 oil at 32.22°-43.33°C (90° - 110°F). Torque is transmitted to the pump gears through an external drive shaft which projects beyond the pump mounting flange.

OPERATING DATA

Capacity	5.1 GPM (at rated pressure)
Speed	2280 to 4200 RPM
Operating pressure	0 to 3000 PSI
Fluid	MIL-L-7808, or MIL-C-8188 at -40° to +176.67°C (-40° to +350°F)
Rotation	Counterclockwise, viewing drive end
Normal inlet pressure range	0-10 psig
Displacement	0.577 cu.in. per revolution
Horsepower (max)	25

NOTE: The thrust reverser pump, before it becomes accessible for removal, requires the removal of the rear gearbox scavenge pump and connecting lines. Refer to section 72-5-5, of the manual for instructions on the removal of the scavenge pump. It is necessary to remove the interlock valve rear bracket to remove the pump.

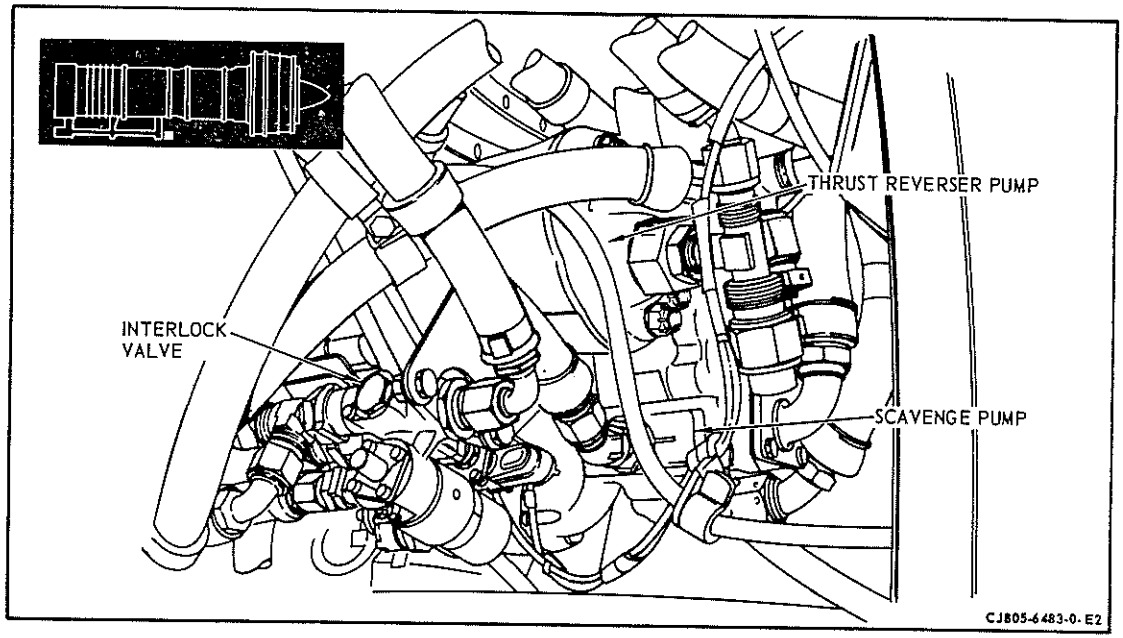
2. Removal/Installation. (See figure 202.)

A. Removal.

(1) Disconnect all lines to the pump and cap to prevent the drainage of the system and contamination.

(2) Remove the pump mounting bolts and remove pump from mounting pad.

Figure 201 Deleted.



Thrust Reverser Pump
Figure 202

B. Installation.

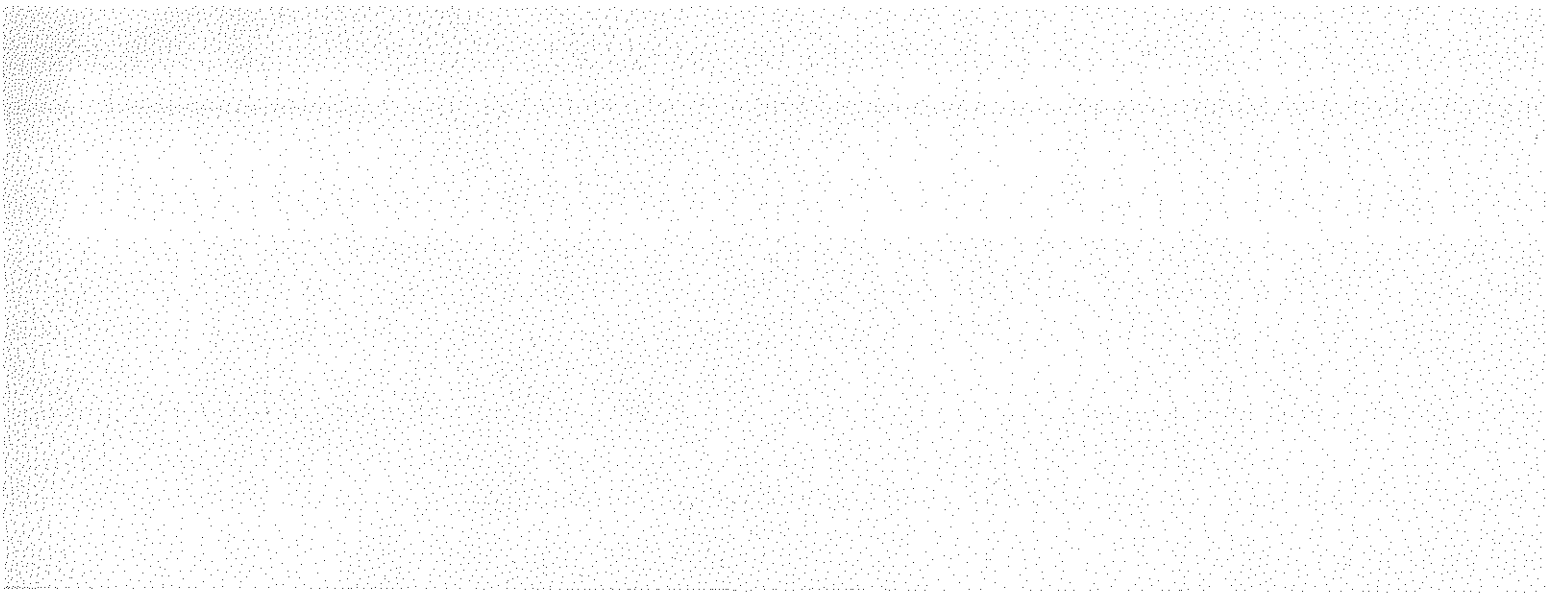
(1) Place the pump with new gasket on the mounting pad on the rear face of the rear gearbox. Position until drive meshes with gear in gearbox and pump connections are properly aligned.

(2) Secure the pump with mounting bolts and connect the lines to the pump. Tighten all bolts and nuts to standard torque values.

system.

OPERATING DATA

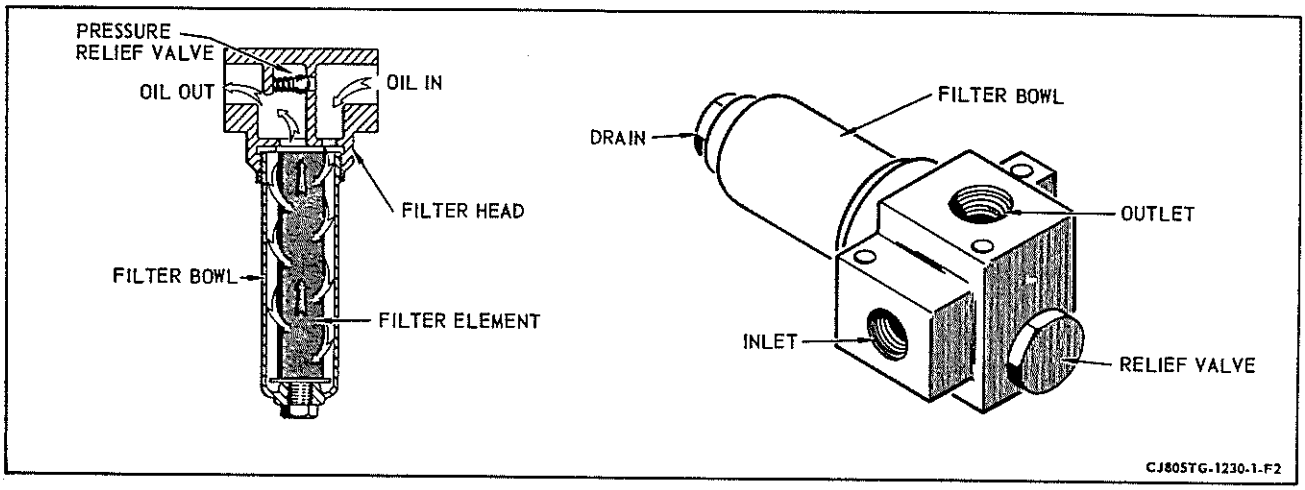
Rated Pressure	3000 psi
Burst Pressure	6000 psi
Temperature Range	-65° to +325°F (-53° to +163°C)
Rated Flow Capacity (using lubricating oil, Specification MIL-L-7808C)	6.5 gpm
Clean Pressure Drop at Rated Flow	13 psi max at 90° to 110°F (32° to 43°C)
Relief Valve Cracking Pressure	17 ± 1.7 psi
Particle Size Removal (Per Specification MIL-F-5504A)	40 microns
Maximum Particle Passed	57 microns
Filter Element	Corrugated Stainless Steel RIGIMESH



THRUST REVERSER FILTER - MAINTENANCE PRACTICES

1. General. The thrust reverser filter element requires periodic cleaning or replacement.

2. Servicing. The thrust reverser filter element may be serviced as follows. Refer to figure 201.



Thrust Reverser Filter
Figure 201

A. Remove drainplug in the filter bowl and allow oil to drain from the filter.

B. Remove the filter bowl from the filter head and separate the element from the bowl.

C. Wash or soak filter bowl and element in gasoline, carbon tetrachloride, trichlorechylene, or similar type of chlorinated hydrocarbon solvent. Use a soft bristled paint brush to remove sludge if necessary.

D. Place cleaned or replacement element in the filter bowl and assemble the bowl on the filter head using a new O-ring washer between the bowl and head.

E. Assemble drainplug in filter bowl, using new O-ring. Lockwire.

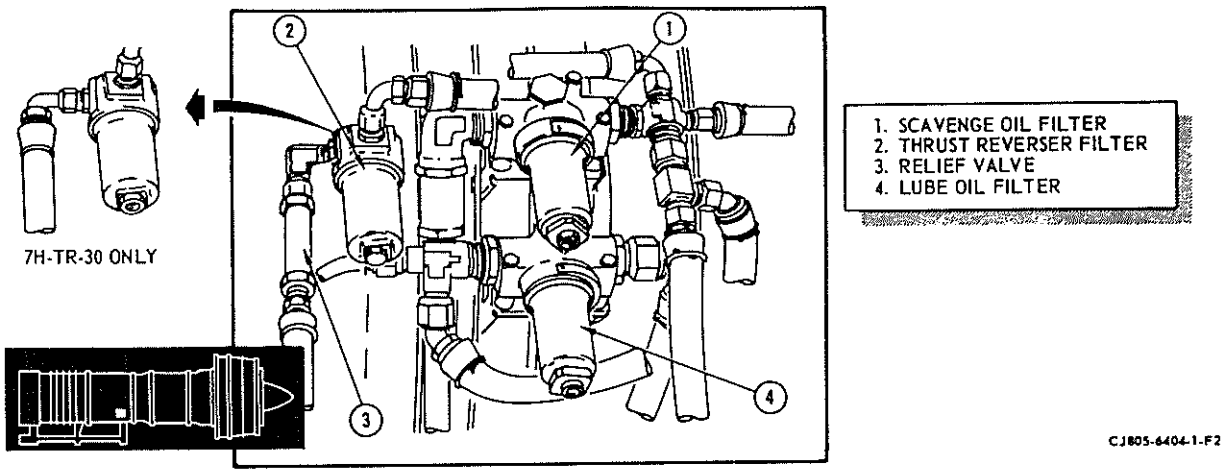
3. Removal/Installation. (See figure 202.)

A. Removal

(1) Disconnect the inlet and outlet lines to the thrust reverser filter.

(2) Remove the mounting bolts securing the filter to the engine, and remove filter.

B. Installation



Thrust Reverser Filter Removal and Installation
Figure 202

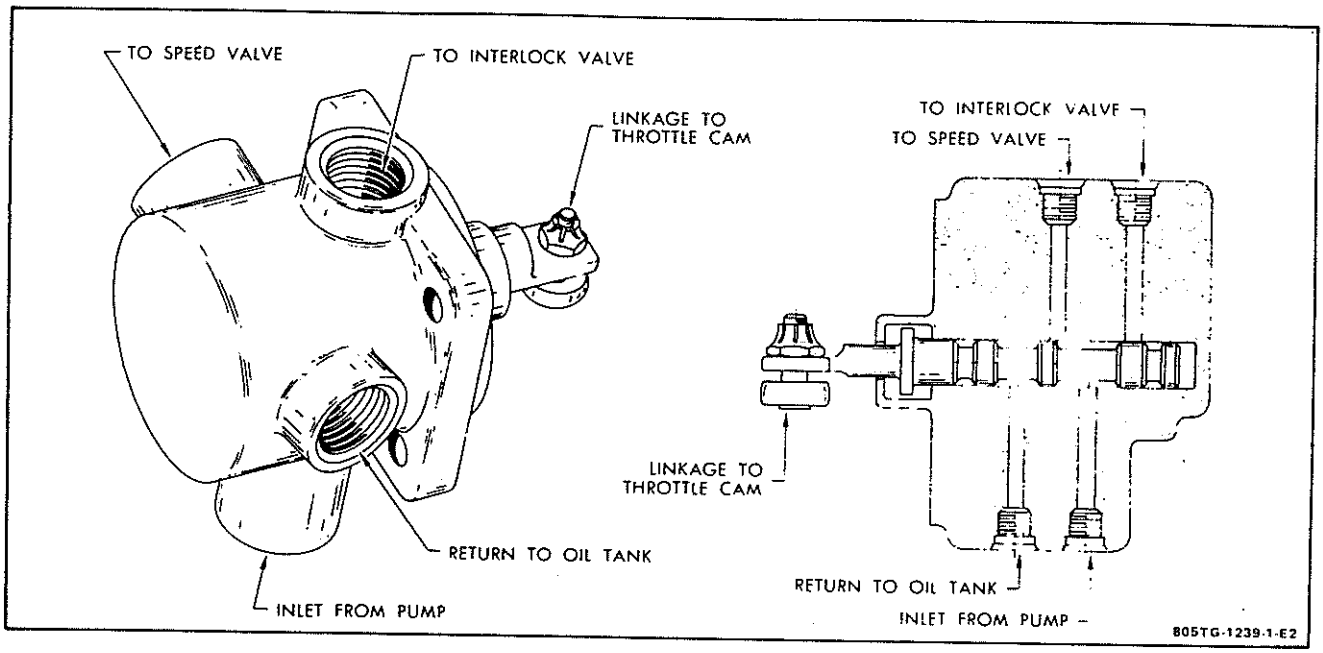
(1) Place the filter on the mounting bracket and secure with mounting bolts.

(2) Connect the inlet and outlet lines to the filter.

4. Inspection/Check. Check the filter for broken areas in the element. None allowed.

5. Approved Repairs. Replace O-rings when making all assemblies after repair or disassembly inspection. Replace element.

THRUST REVERSER SELECTOR VALVE - DESCRIPTION AND OPERATION



Thrust Reverser Selector Valve
Figure 1

1. General. (See figure 1.)

   A. The selector valve is a 4-way, 2-position mechanical input valve. It is designed to port high-pressure oil to either end of the thrust reverser actuators in response to throttle position.

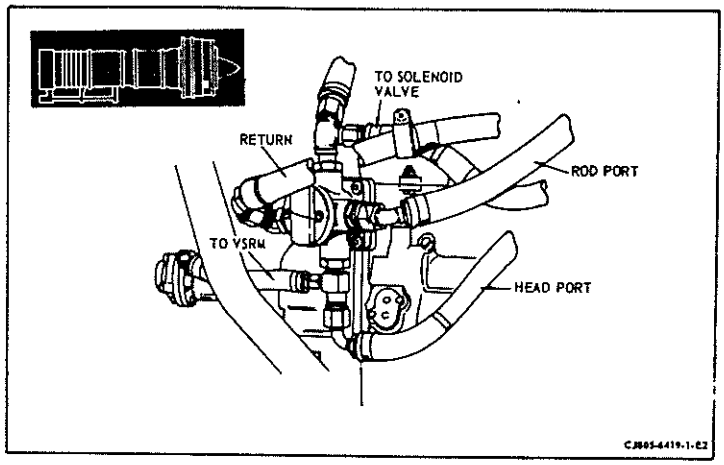
   B. The selector valve is mounted on the airframe supplied throttle housing, which is attached to the fuel control. The valve is actuated, through a rod and spherical bearing, by a cam in the sheave housing. Thrust reverser pump discharge pressure is applied to the selector valve piston. With the power lever in the forward thrust region, the selector valve directs pump discharge pressure, through one of the speed metering valves, to the head end of the blocker door actuators. When the power lever is retarded to the reverse thrust region, the selector valve piston directs pump discharge pressure to the interlock valve power piston. The power piston then applies high-pressure oil to the rod end of the actuators. Oil displaced from the head end of the actuator pistons is returned through the speed metering valves and the selector valve case to the thrust reverser section of the oil tank.

OPERATING DATA

Operating Pressure	3000 psig
Fluid	MIL-L-7808C
Port Thread Sizes (All ports)	3/4-16 UNF-3B per AND10050-8
Full Travel	0.200 in. (min.)
Travel for Full Reverse	0.040 in. (max.) from neutral

THRUST REVERSER SELECTOR VALVE - MAINTENANCE PRACTICES

1. General. The thrust reverser selector valve maintenance is limited to replacement of the complete valve, therefore, removal and installation will be the only maintenance described.



Thrust Reverser Selector Valve
Figure 201

2. Removal/Installation. (See figure 201.)

A. Removal

NOTE: It is recommended that the inspection plate be removed from the engine torque box prior to removal of the thrust reverser selector valve.

(1) Disconnect all lines to the selector valve.

(2) Remove the bolts that secure the selector valve to the throttle torque box.

(3) Pull the selector valve to disengage the throttle cam linkage.

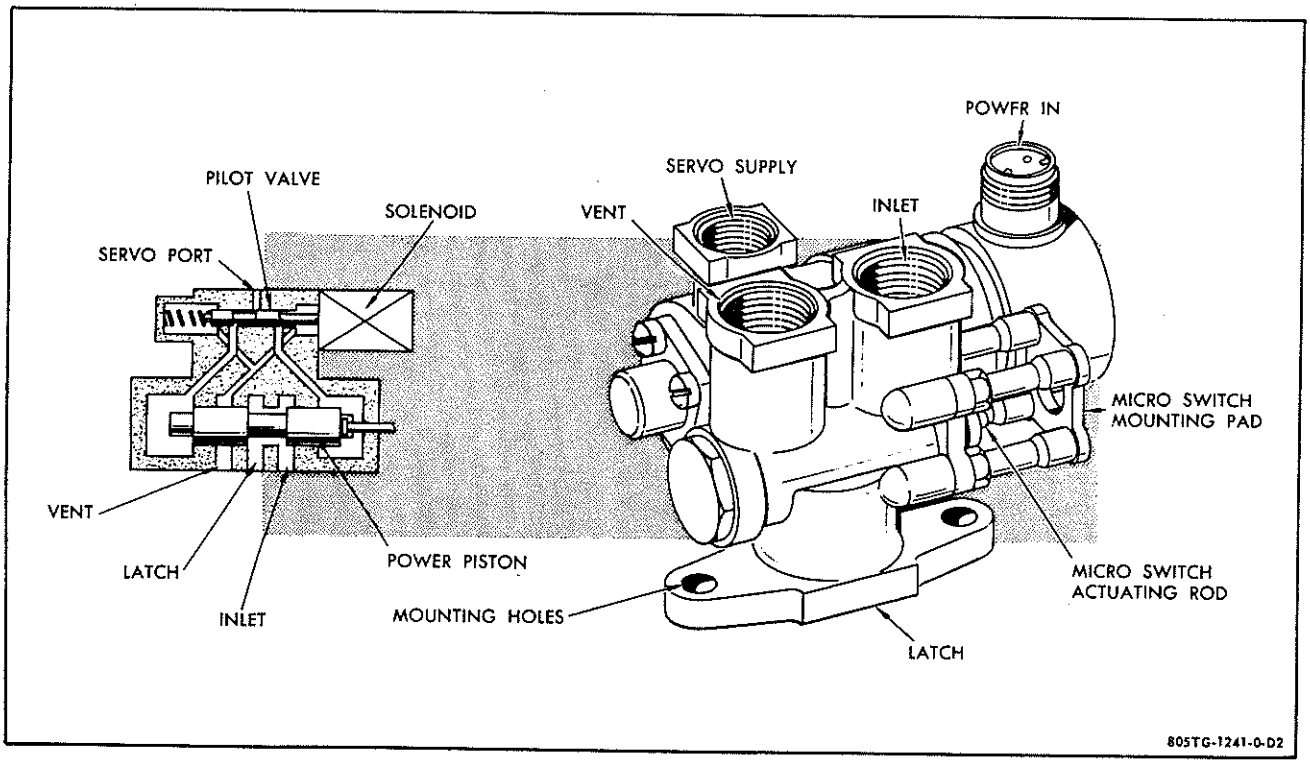
B. Installation

(1) Engage the throttle cam linkage and seat the selector valve on the throttle torque box mounting pad.

(2) Install mounting bolts to secure the selector valve.

(3) Connect all lines to the selector valve.

THRUST REVERSER INTERLOCK VALVE - DESCRIPTION AND OPERATION



Interlock Valve
Figure 1

1. General. (See figure 1.)

   A. The interlock valve is a 2-position, 3-way power piston hydraulically actuated by a solenoid-operated pilot valve. It supplies oil at pump discharge pressure to the rod ends of the blocker door actuators and the head ends of the latch actuators, or vents these areas to the oil tank as a function of throttle lever position.

   B. The electrical supply to the solenoid is controlled by an aircraft switch which is actuated by the throttle lever. When the solenoid is de-energized (forward thrust) the pilot valve ports oil at pump discharge pressure, which enters the valve through the servo supply port, to one end of the power piston. The power piston is positioned to block the inlet port and allow flow from the latch port to the vent port. Oil displaced from the low-pressure side of the actuators flows in the latch port and is routed through the vent port to the oil tank.

C. Moving the throttle to the reverse thrust position energizes the interlock valve solenoid. The push-type solenoid moves the pilot valve to port high-pressure oil to the opposite end of the power piston. The high-pressure oil positions the power piston so that it ports high-pressure oil from the inlet port out the latch port to the actuators.

D. Operating voltage and frequency ranges to the solenoid are 102-124 V ac and 380-420 cps. Normal valve operating pressure is 1800 psi. No external leakage is permissible.

THRUST REVERSER INTERLOCK VALVE - MAINTENANCE PRACTICES

1. General. The thrust reverser interlock valve requires no periodic maintenance service, therefore, only the removal and installation is the extent of the maintenance that may be performed.

2. Removal/Installation. (See figure 202.)

A. Removal.

(1) Disconnect all lines to the interlock valve including the micro switch connection and line to the solenoid.

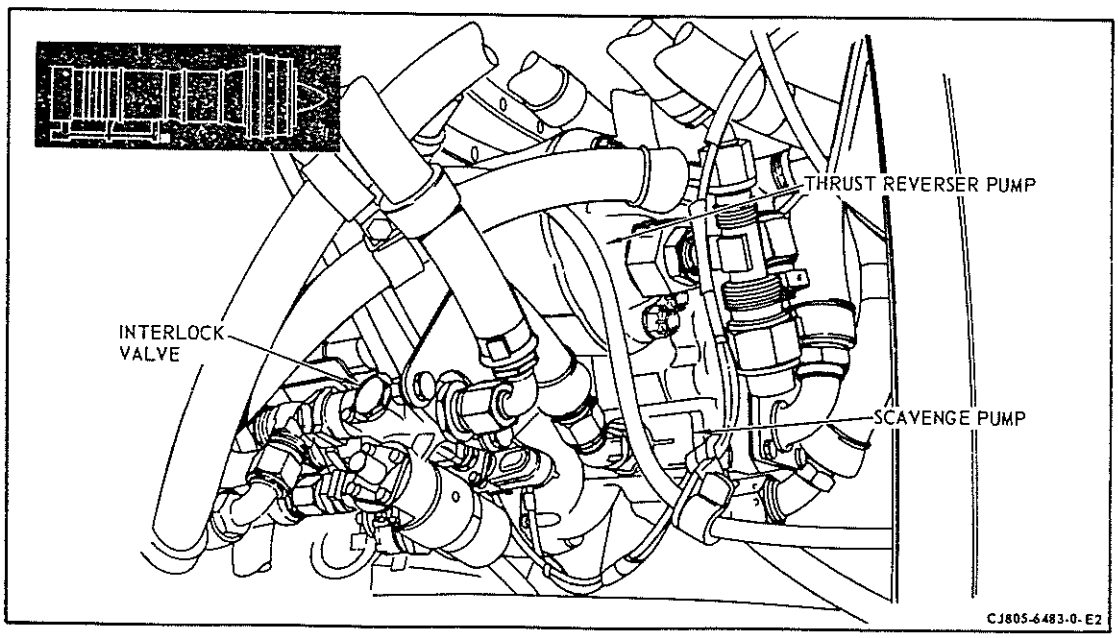
(2) Remove the mounting bolts and remove the interlock valve from the brackets.

B. Installation.

(1) Install the interlock valve on the brackets and secure with mounting bolts.

(2) Connect all lines to the interlock valve. Make micro switch and solenoid connections.

Figure 201. Deleted.



Thrust Reverser Interlock Valve
Figure 202

THRUST REVERSER SPEED-METERING VALVES - DESCRIPTION AND OPERATION

1. General.

   A. The speed-metering valves are installed in-line in the thrust reverser hydraulic system. Their combined functions form a thrust reverser speed limiting system which provides unrestricted flow for the stowing operation, provides a dash pot action to retard the thrust reverser actuator motion near the reverse thrust position to reduce blocker door impact and maintains lower system pressure when in the reverse thrust position.

OPERATING DATA

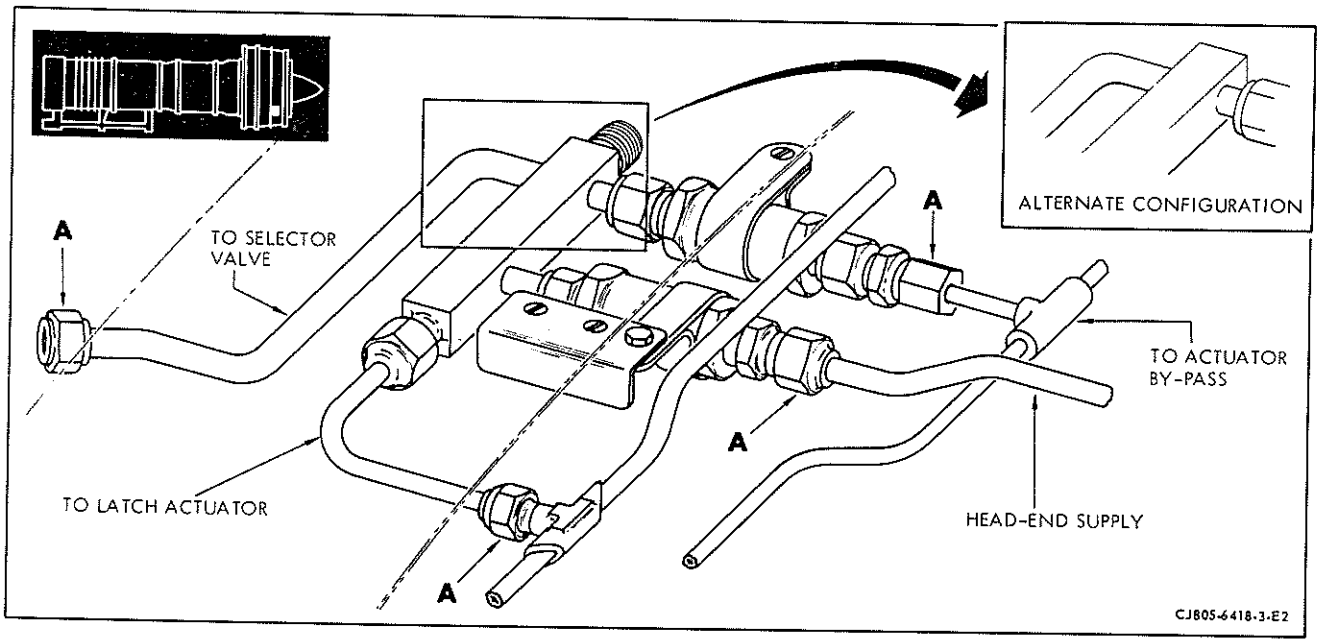
Fluid ..... Oil, per Specification MIL-L-7808C

Operating Pressure (Maximum) ..... 3000 psig

THRUST REVERSER SPEED-METERING VALVES - MAINTENANCE PRACTICES

1. General. The thrust reverser speed-metering valves require no maintenance other than removal and installation when defective.

2. Removal/Installation. (See figure 201.)



Thrust Reverser Speed-Metering Valves
Figure 201

A. Removal.

(1) Cut the lockwire at the connections marked A on figure 201 and disconnect the lines.

(2) Remove the bolts securing the valve retaining clamps to the aft fan shield.

(3) Remove the valves and piping from under the fan shield.

(4) Remove the valves from the lines.

B. Installation.

(1) Attach the valves to the assembled lines. Torque and lockwire.

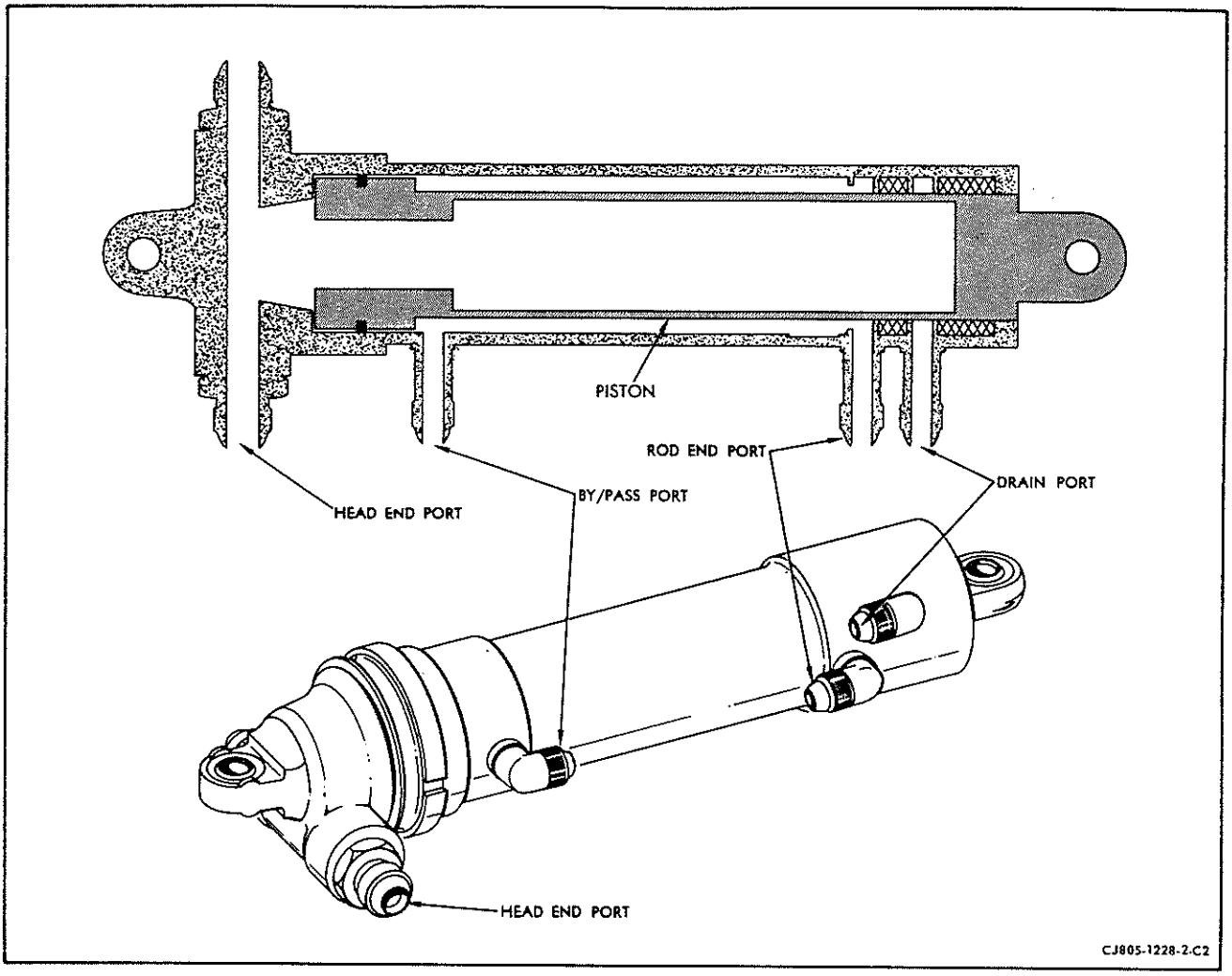
(2) Install clamps and brackets on the valves and lines.

(3) Insert the assembly under the fan shield and connect lines. Torque and lockwire.

(4) Secure the valve retaining brackets to the fan shield with bolts. Torque and lockwire.

(5) Actuate the thrust reverser system and check for leaks.

BLOCKER ACTUATORS - DESCRIPTION AND OPERATION



Blocker Actuator
Figure 1

1. General. The blocker door actuators convert hydraulic pressure into mechanical force to position the thrust reverser blocker doors.

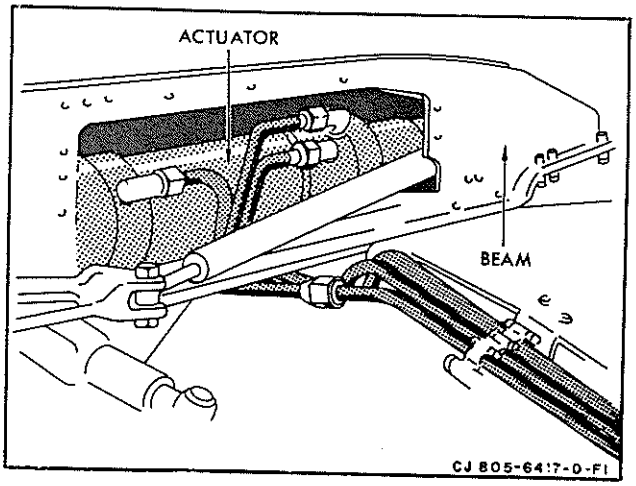
2. Description. The actuators are single-ended, uncushioned hydraulic cylinders. They are mounted on the fan front frame, one at the 12 o'clock position and one at the 6 o'clock position. Each actuator is pinned to the fan frame mounting boss at the head end, while the rod end is attached to the reverser linkage slider. The actuator is shown in figure 1.

3. Operation. Application of high pressure to the head end of the actuator extends the actuator rod, stowing the thrust reverser blocker doors. When the pressure is reversed and high pressure is applied to the rod end, the actuator rod is retracted, moving the reverser doors to the reverse thrust position. Rated loads of the actuator during transients is 3000 lb max in tension and 8500 lb max in compression.

BLOCKER ACTUATORS - MAINTENANCE PRACTICES

1. General. The blocker actuators can be removed with the engine and reverser installed in the airframe. The top actuator may be removed through a side access panel in the upper support beam and the bottom actuator through the bottom access panel in the lower beam. Maintenance is limited to removal and replacement.

2. Removal/Installation. (See figure 201.)



Blocker Actuators
Figure 201

A. Removal

NOTE: This procedure may be followed to remove the top actuator through the side access panel of the upper beam. Similar steps may be followed to remove the bottom actuator.

(1) Remove the side cover from the upper beam.

(2) Disconnect the link rods between the actuators and the bellcranks at the bellcrank.

(3) Remove the actuator head end and rod end mounting studs. Remove the actuator.

B. Installation

(1) Place the actuator in the beam and secure the rod end to the slider and the head end to the beam.

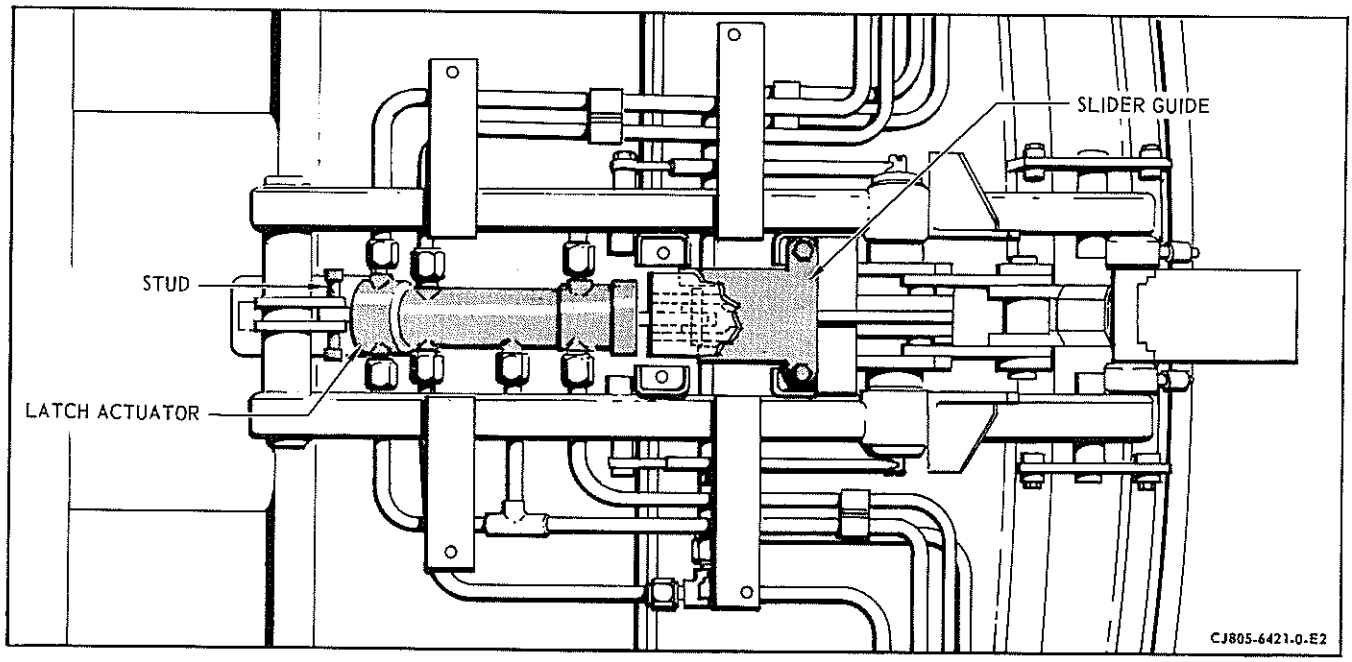
(2) Connect the links between the actuator and the bellcranks at the bellcranks.

(3) Install side cover on upper support beam.

LATCH ACTUATORS - MAINTENANCE PRACTICES

1. General. Maintenance of the latch actuators is limited to removal and replacement of defective actuators with a serviceable replacement part.

2. Removal/Installation. (See figure 201.)



Latch Actuators
Figure 201

A. Removal

(1) Remove the section of the aft fan shield that cover latch assembly.

(2) Disconnect the piping to the actuator.

(3) Remove the stud that secures the head end of the actuator to the latch frame.

(4) Remove the bolts securing the slider guide to the latch frame. Slide the slider guide off the slider.

(5) Remove the pin securing the slider to the rod end of the actuator and link.

(6) Loosen the brackets securing the tubing to the actuator. Spread the tubing to free the actuator for removal, and remove.

B. Installation

(1) Install the actuator in the latch frame so the tubing connections line up with the actuator connections.

(2) Assemble the link, slider and latch rod end with pin.

(3) Assemble the slider guide in place and secure the latch frame.

(4) Assemble the stud in the latch frame and head end of actuator. Torque castle nuts to 10 lb-in. maximum and back-off, if necessary, to insert cotterpin.

(5) Connect the piping to the actuator and lockwire.

(6) Install the section of the aft fan shield that covers the latch assembly and secure with bolts.

Description - Power Plant, Fuel and Oil Systems

OIL SYSTEM

01. GENERAL (cont'd)

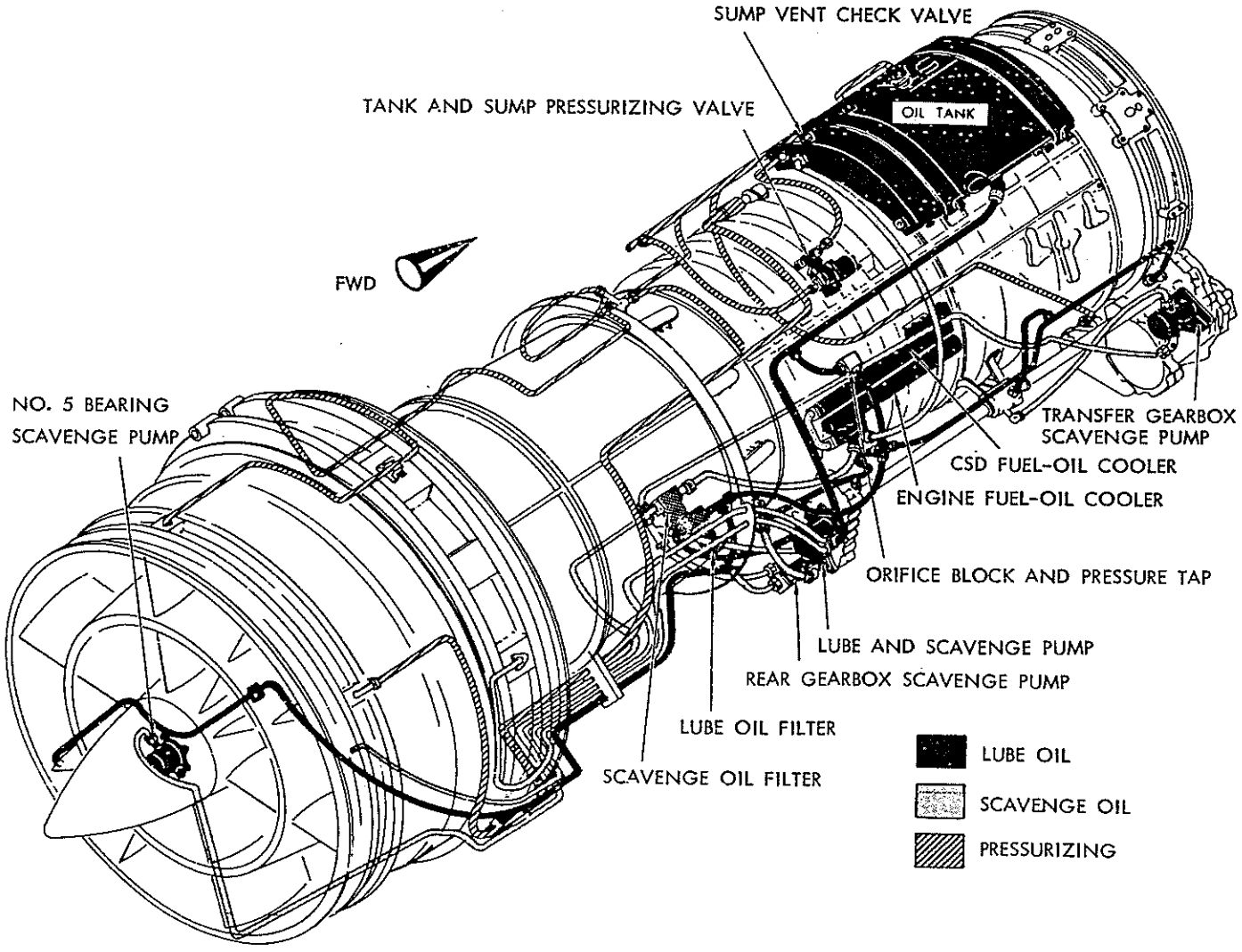


Fig 2 - Engine oil system (engine layout)

(more)

02. MAIN COMPONENTS AND SUB-SYSTEMS

(1) Oil supply sub-system

The oil tank is divided into 2 sections, namely the engine section and the constant speed drive section. Oil from the engine section is gravity fed to the lube element of the main lube and scavenge pump which discharges the oil, through an anti-leak check valve, to the lube oil filter. Filtered oil flows to a tee and divides to supply the front gearbox, No. 1 bearing, the transfer gearbox and the horizontal drive shaft bearing forward of the filter. The other branch flows aft to supply the rear gearbox, fan tachometer generator and main bearings No. 2, 3, 4 and 5.

The smaller section stores the oil used as the hydraulic medium in the thrust reverser and constant speed drive systems.

(2) Scavenge sub-system

Lube oil, as it is sprayed over the bearings and gears, absorbs heat and picks up metal particles or contamination from the gears. In order to use this oil again as a lubricant, it must first be cleaned and cooled. The scavenge sub-system performs these functions and returns the oil to the oil tank in condition for re-use in the oil supply sub-system.

The lube system is of the "dry sump" design. That is, all sump areas are constantly pumped dry of oil by the scavenge pumps. The capacity of the scavenge sub-system is approximately 2,5 times as great as the amount of the lube oil distributed in any one area. The balance is made up of sump pressurizing air. The advantages of this type of system in a jet engine are:

(a) Reduction in oil foaming.
(b) Reduction in gear drag.
(c) Reduction in temperature buildup within gearcases and bearing areas.
(d) Contributes to the design of a minimum volume lubrication system.

(3) Sump and tank pressurizing sub-system

The sump and tank pressurizing sub-system (see Fig 3) regulates the pressure of the air in the oil tank, the gearboxes and bearing sumps. These units are pressurized to assure a positive pressure at the inlet of the lube and scavenge pumps.

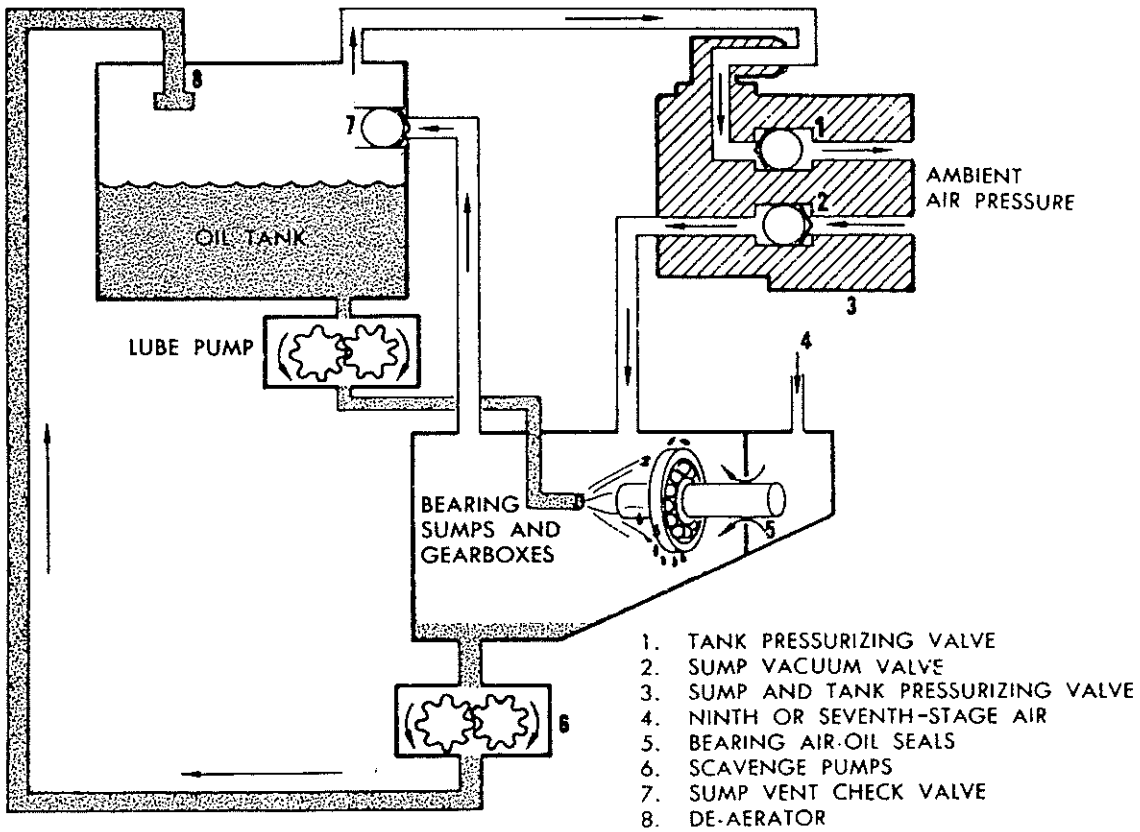


Fig 3 - Sump and tank pressurization sub-system

(more)

Description - Power Plant, Fuel and Oil Systems

OIL SYSTEM

(3) Sump and tank pressurizing sub-system (cont'd)

The sump and tank pressurizing sub-system includes the airspace above the oil level in the oil tank, bearing sumps, gearboxes and the interconnecting lines. The scavenge pumps are also a part of the pressurizing system, at least in that they pump large quantities of air from the sumps to the oil tank and thereby affect air pressures in both areas.

Seventh and ninth stage compressor air bleeds across the bearing oil seals pressurizing the 5 bearing sumps and 3 gearboxes. These areas are connected by a manifold and vented to the oil tank through a 0,25 psi sump vent check valve mounted in the oil tank sump vent port. If sump pressure exceeds tank pressure by 0.25 psi, the check valve opens, allowing the excess sump air to enter the oil tank.

Tank pressure is established at 3-6 psi above ambient pressure by the sump and tank pressurizing valve.

At certain engine speeds, the ability of the scavenge pumps to pump air forms a vacuum in the sumps. Since the scavenge pumps can be damaged by operating them in too great a vacuum, a sump vacuum relief valve in the sump and tank pressurizing valve opens at negative 2 to 3 psi allowing air to enter the sump.

(4) Oil tank

The 2-section oil tank is attached to the right hand side of the engine, over the upper half of the compressor forward casing (see Fig 2). The oil in one section is for the oil supply sub-system and the oil in the other section is used as a hydraulic medium in the thrust reverser and constant speed drive systems

	Useable capacity	Expansion space
Engine section:	4,1 gal	1,2 gal
Constant speed drive section:	1,7 gal	0,5 gal

Oil level is indicated by a remote type indicator located on the flight engineer's engine oil instrument panel.

(5) Lube and scavenge pump

The lube and scavenge pump is mounted on the rear face of the rear gearbox in the 6 o'clock position (see Fig 2).

It serves a dual purpose pumping both lubricating oil and scavenge oil simultaneously. One element receives oil at tank pressure and discharges oil at higher pressures to the lube oil filter. The 2 other elements scavenge oil from the No. 3 and 4 bearing sumps. This oil is discharged to the scavenge oil filter.

(6) Lube oil filter and scavenge oil filter

The same type filter is used for both the lube oil and the scavenge oil. The filters are a full flow type and are mounted adjacent to each other on the compressor rear casing in the 8 o'clock position (see Fig. 2). If the filter becomes clogged, oil is re-routed through the relief valve to the discharge port.

(7) Oil pressure tap, lube distribution manifold

Contains 2 calibrated orifices which work with a pressure relief valve to protect the oil pressure transmitter from extreme pressure surges (see Fig 2).

(8) Scavenge pumps

3 separate scavenge pumps (and the lube and scavenge pump, see (5) above) scavenge used oil from the rotor bearings, the gearbox and the fan tachometer. This oil is discharged to the scavenge oil filter. The location of the pumps is shown in Fig 2.

(9) Engine fuel-oil cooler

The engine fuel-oil cooler is a liquid-to-liquid heat exchanger which uses engine fuel as the coolant. The cooler is capable of transfering all the heat necessary to keep the oil temperature within the prescribed limits, at the same time keeping the engine fuel within temperature limits. Oil discharged from the cooler returns to the oil tank.

(10) Constant speed drive fuel-oil cooler

The constant speed drive oil cooler is identical to the engine oil cooler. The coolers are mounted on the rear compressor stator casing in the 3 o'clock position (see Fig 2).

(11) Sump and tank pressurizing valve

The sump and tank pressurizing valve has the dual function of maintaining the proper air pressure in the oil tank, the gearboxes and the engine bearing sumps. This is achieved by admitting air to the sumps or releasing air from the tank through a pair of check valves mounted within the pressurizing valve casing (see Fig 2).

(12) Sump vent check valve

If sump pressure exceeds tank pressure by 0,25 psi, the check valve opens allowing the excess sump air to enter the oil tank. The valve allows flow into the tank only so that oil or tank vapours cannot back-up into the sump areas.

CHAPTER 89 - STANDARD PRACTICES

89-0 STANDARD PRACTICES - GENERAL

89-1 ENGINE STANDARD PRACTICES

- 89-1-1 Assembly and Disassembly Techniques
- 89-1-2 Cleaning
- 89-1-3 Repair
- 89-1-4 Refinishing
- 89-1-5 Standard Torque Values
- 89-1-6 Engine Preservation
- 89-1-7 Accessory Preservation
- 89-1-8 Inspection Methods

89-20 AIRCRAFT STANDARD PRACTICES (Refer to Aircraft Maintenance Manual.)

STANDARD PRACTICES

1. General. This chapter covers processes and procedures which are used many times on many different parts and operations. These processes and procedures are, for the most part, standard General Electric or Convair processes or procedures. Processes or procedures which are standard to the aircraft industry are not covered in this chapter or in this manual. The standard practices covered in this chapter can be generally categorized into 8 basic sections:

   Assembly and Disassembly Techniques

   Cleaning

   Repair

   Refinishing

   Standard Torque Values

   Engine Preservation

   Accessory Preservation

   Inspection Methods

ASEEMBLY AND DISASSEMBLY TECHNIQUES

1. General. This section, covering techniques for assembly or disassembly, will assist the mechanic while performing his duties.

   A. Cleanliness. Cleanliness is of utmost importance in assembly or disassembly work. Preventing foreign material from lodging in drilled passages, fuel lines, oil lines, air lines and engine parts is extremely important. Do not remove plugs or caps from openings until connections are to be made.

   B. Precautions. Exercise extreme care during assembly or disassembly operations so that pieces of lockwire, nuts, washers or any other objects do not fall into the engine or assembly. If anything is dropped into the engine or assembly during assembly, stop the assembly and locate the object before proceeding with the assembly. The following precautions must also be observed.

      (1) All lockwiring must be done according to instructions given in step "2" of this section.

      (2) Refer to 89-1-5 for standard torque values. Torque all nuts, screws and bolts at diametrically opposite points where possible. Special torques will be included in the detailed procedures for the assembly operation that would require special torques.

      (3) Refer to the Illustrated Parts Catalog, GEI 67828 for detailed information on engine parts.

      (4) Use specified anti-seize compound as required for bolts and screws at assembly.

      (5) Always use fiber or plastic blocks and soft hammers for driving operations when assembling parts.

2. Lockwire Procedure.

   A. General. Observe the following general rules in using lockwire unless specific instructions to the contrary are given in the test. Standard methods, and permissible deviations from them, are illustrated in figure 1.

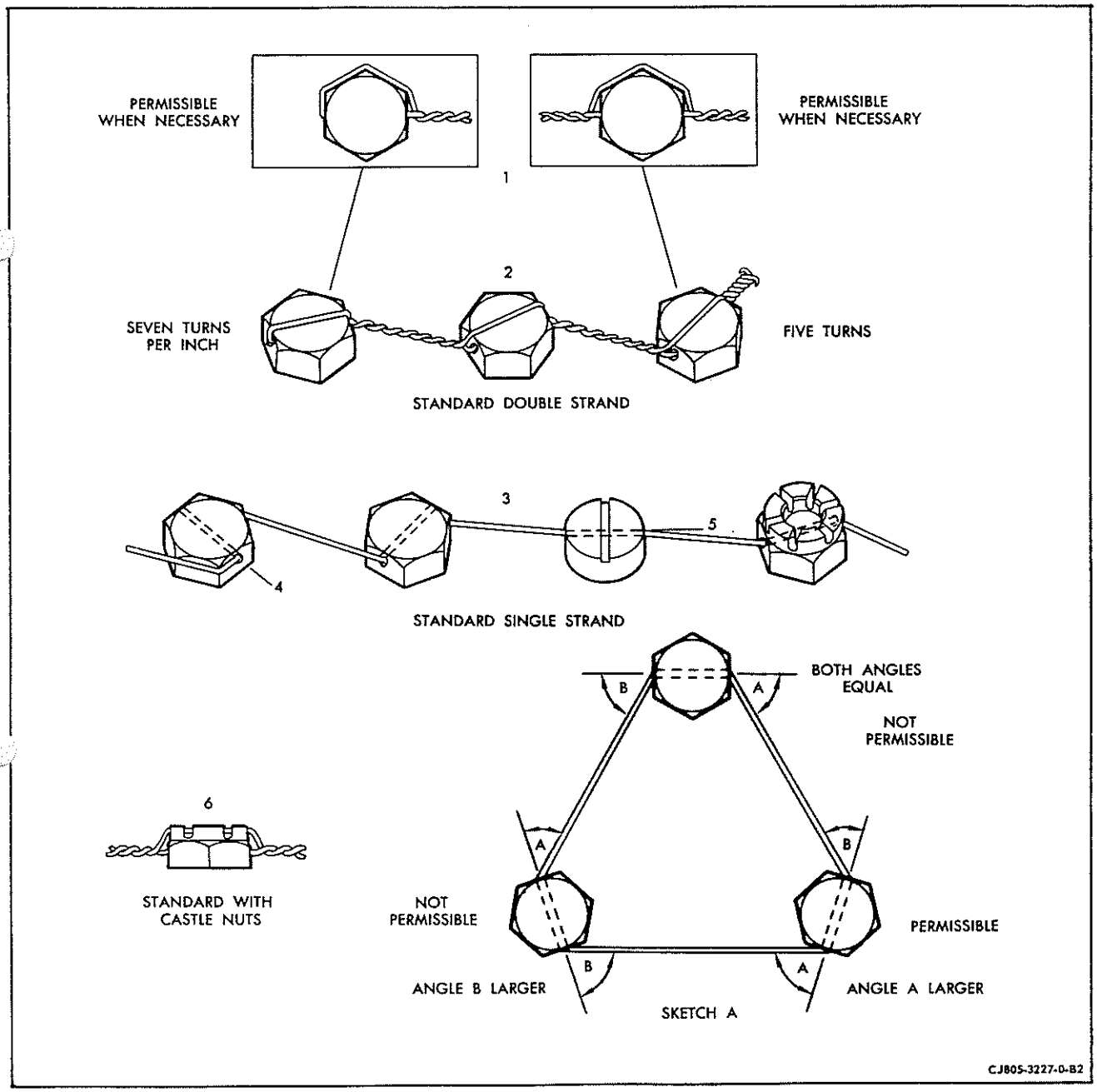
   B. Procedures.

      (1) Double-strand lockwire will be used throughout the assembly of the engine unless otherwise specified.

      (2) To lockwire studs, screws, bolts or other fasteners in a series, use 2 strands of lockwire, passing one wire through the fixture and the other over it as shown in (2), figure 1. If one strand cannot be passed over the fastener, the strand may be led around it (1). If castellated nuts are wired, the wire must be passed over the top of the nut (6). Single-strand lockwire may be used in special inacces-

sible locations where it would be difficult to twist double strands (3). Specific reference will be made to such inaccessible locations.

NOTE: Any number of studs, screws, or bolts may be lockwired together as long as the arc formed by the centerline through the bolts does not exceed 180 degrees. The only exception is when 3 bolts form a triangle and there is no means of lockwiring except to each other.



Lockwire Procedures
Figure 1

(3) Double-strand lockwire will be twisted uniformally, at about 7 turns per inch, to prevent the wire from slipping through the fastener. The wire will be twisted at least 5 times at the end of a series before it is cut off. Bend back the ends to prevent snagging.

(4) On assemblies which require lockwire, wire the fasteners either to a fixed point or to each other. Wire more than 2 studs, screws or bolts together where possible to reduce the number of fasteners that would come loose if the wire broke. Fasteners lockwired together on a common axis must also be secured to a fixed point.

NOTE: While a straight-away pull is permissible, it is not considered the best pracitce. A negative pull is not acceptable under any circumstance.

(5) Install lockwire so that the greater tension will be placed on the wire if the bolt, screw, stud or plug starts to loosen. If screw, (6) figure 1, were 5 degrees tighter, it would be wired the same as bolt (4).

(6) In a series of fasteners which are not in a straight line, the lockwire may tend to both loosen and tighten the fastener. In such cases, arrange the lockwire so that the force tending to tighten the fastener is greater than the force tending to loosen it. To determine the strength of these forces, extend a line through the fastener in line with the lockwire (figure 1, sketch A). The angle between this line and the lockwire which tends to tighten the fastener must be larger than the angle between the line and the lockwire which tends to loosen the fastener. (Angle A must be greater than angle B.)

NOTE: Use 0.032-inch diameter lockwire (heat and corrosion resistant) throughout the engine unless otherwise stated for one specific component.

CLEANING

1. General. The inspection of the component parts of a jet engine is essential to determine the extent of defects. Parts must be clean in order to perform this inspection. The parts and/or areas that are inspected at the maintenance level operate at relatively cool conditions, with the exception of the exhaust system. Therefore, most parts will be contaminated with only oil, dirt and dust, which can be removed by solvents.

2. Solvent Cleaning.

   A. General. Two types of petroleum distillates employed in this cleaning procedure are referred to commercially as "Stoddard Solvent" and "140°F Solvent".

   B. Uses of Solvents. Both solvents are widely used for cleaning metal parts, especially where there are deposits of oil, grease and dirt. These solvents are adaptable to any method of hand cleaning. Stoddard Solvent is comparatively safe, but it has a flash point of 100°F. For this reason 140°F Solvent, which has a flast point of 140°F, is preferred when it is available. The solvents are generally used for hand cleaning by such methods as atomized spray, brush, immersion, dipping and wiping.

REPAIR

1. General. This section will include repair procedures which are common to more than one part on the engine. Some of these procedures may be standard to the industry, but only those which are standard to the CJ805-23 engine are included in this section.

2. Blending Procedures.

   A. General. Blending is a repair procedure which is used to remove stress concentration caused by nicks, scratches, etc. on critical parts. Removing the material surrounding stress concentration in a smooth contour relieves this stress concentration and permits further use of the part by lessening the danger of cracking.

   B. Procedures.

      (1) Blending may be done by using an Arkansas stone, a fine file or crocus cloth. If a large or deep blend is to be made, a medium file or heavy grade abrasive paper may be used to shorten the time required to remove the metal, but a fine finish must then be applied.

      (2) When blending compressor rotor blades, turbine buckets and similar parts, the part will be blended in a radial direction in relation to the engine. When blending the edge of a turbine bucket or compressor rotor blade a minimum thickness of 0.015 inch must be maintained on the edge of the blade or bucket. If a sharp or feather edge is made while blending the sides of an edge, the edge must be blended back until the minimum thickness of 0.015 inch.

      (3) When blending a cylindrically shaped part, the blend must be done in a circumferential direction, not along the axis of the part.

      (4) The finish on the blended area must be as close as practical to the original finish of the part.

3. Replacement of Tap-Lok Inserts. The following procedure is recommended for the replacement of Tap-Lok inserts in magnesium allow castings.

   A. Remove damaged insert by unscrewing or using "ezy-out" to remove the insert from the casting.

   B. Drill to the required depth, but no deeper than the original pilot hole. Use drill size recommended for replacement or oversized Tap-Lok insert to be installed. Allow a minimum wall thickness of 0.060 inch (figure 1).

   C. Countersink to the required diameter for the replacement or oversized insert.

   D. Treat the hole with dichromate solution.

E. Coat the external threads of the replacement or oversized insert with zinc chromate primer.

F. Drive Tap-Lok insert to 0.005-0.010 inch below surrounding surface.

NOTE: The Tap-Lok Insert Driver is illustrated in figure 2. The driver and replacement or oversize inserts may be obtained from the Groov-Pin Corporation, Ridgefield, N. J.

4. Repair of Blind - Threaded Holes in Castings. The following procedure is recommended.

A. Drill and tap damage hole for an aeronautical pipe thread plug, if outside wall thickness permits (figure 3). Recess bottom of hole to prevent tap bottoming.

(1) The minimum outside wall thickness A must not be less than 1/8 inch.

(2) The minimum wall thickness of the bushing B must not be less than 1/16 inch.

INTERNAL THREAD	LENGTH	STANDARD PART NO.	A. .005 OVERSIZE PART NO.	B. SK SERIES PART NO.	EXTERNAL THREAD	RECOMMENDED HOLE SIZE	NEAREST DRILL SIZE	C. PART NO.	EXTERNAL THREAD	RECOMMENDED HOLE SIZE	NEAREST DRILL SIZE
10-32	0.484	H 19032	OH 19032	SK 855	3/8-20	.343-.353	S (.348)	SK-882	15/32-18	.440-447	
10-32	0.250	HS 19032	OHS 19032	SK 856	3/8-24	.343-.353	S (.348)	SK-884	15/32-18	.440-.447	
1/4-28	.484	H 25028	OH 25028	SK 764	15/32-20	.433-.443	7/16 (.438)	SK-889	9/16-16		17/32
1/4-28	.375	HM 25028	OHM 25028	SK 784	15/32-18	.433-.443	7/16 (.438)	SK-885	9/16-20		17/32
1/4-28	.312	HS 25028	OHS 25028	SK 763	15/32-18	.433-.443	7/16 (.438)	SK-888	9/16-20		17/32
5/16-24	.562	H 31224	OH 31224	SK 765	9/16-16	.521-.534	17/32 (.531)	SK-890	41/64-14		39/64
5/16-24	.469	HM 31224	OHM 31224	SK 785	9/16-16	.521-.534	17/32 (.531)	SK-886	41/64-14		39/64
3/8-24	.687	H 37524	OH 37524	SK 766	41/64-14	.594-.609	19/32 (.594)	SK-891	47/64-13		45/64
3/8-24	.562	HM 37524	OHM 37524	SK 767	41/64-14	.594-.609	19/32 (.594)	SK-892	47/64-13		45/64
7/16-20	.656	HM 43720	OHM 43720	SK 768	47/64-13	.684-.699	11/16 (.688)	SK-893	13/16-12		25/32
1/2-20	.750	HM 50020	OHM 50020	SK 786	13/16-12	.759-.768	49/64 (.766)	SK-887	29/32-11		55/64

A— .005 OVERSIZE BUSHING TO BE USED WHEN STANDARD BUSHING BECOMES LOOSE.

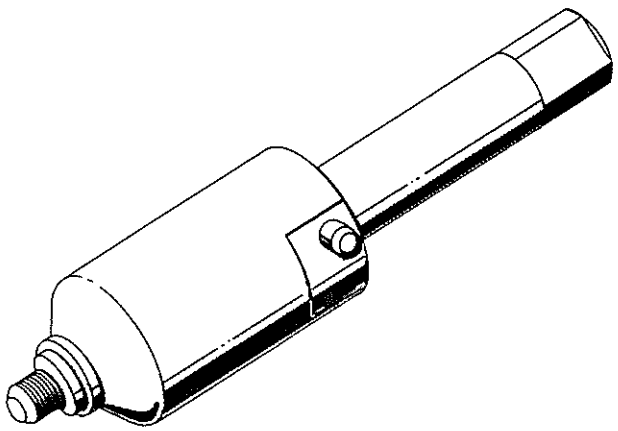
B— BUSHING TO BE USED WHEN A STANDARD OR .005 OVERSIZE BUSHING HAS PULLED OUT.

C— BUSHING TO BE USED WHEN SK SERIES HAS PULLED OUT.

CJ805-6370-0-F2

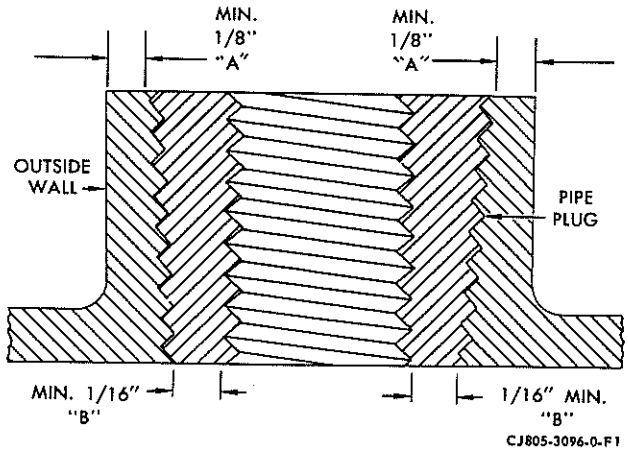
Tap-Lok Replacement Inserts
Figure 1

e sol



CJ805-3008-0-E1

Tap-Lok Insert Driver
Figure 2



Repair of Open - Threaded Holes
Figure 4

(1) The minimum outside wall thickness A must not be less than 1/8 inch.

(2) The minimum wall thickness of the bushing B must not be less than 1/16 inch.

B. Fabricate a pipe plug to fit through the tapped hole. Use magnesium alloy Dow Metal "C", or equivalent.

C. Treat the pipe plug and threaded hole with dichromate solution.

D. Coat the external and internal threads with zinc chromate primer.

E. Install plug, and tighten to 150 pound-inches torque.

F. Machine, drill, tap and chamfer to blueprint specifications. Blend inside to original casting contour.

G. Drill and install locking pin.

H. Peen metal over head of pin.

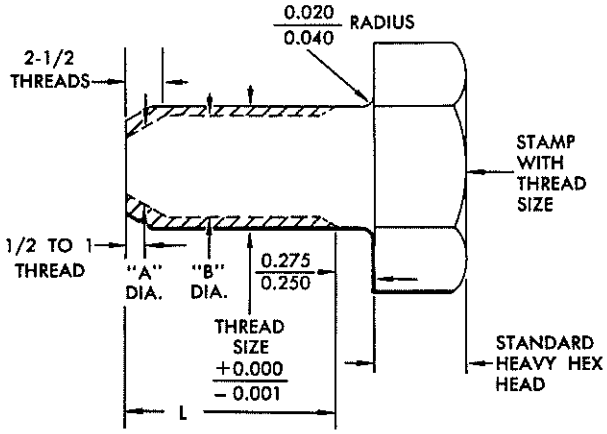
I. Treat entire repaired area with dichromate solution.

J. Press check per blueprint specifications. No leakage is permitted.

6. Removal and Replacement of Lok-Thread Studs. The following procedure is recommended.

A. Remove the damaged stud.

NOTE: If studs are being replaced because of oil leakage, use Loctite Sealant, Grade "A" (American Sealants Company, Hartford 6, Conn.) on both the stud and threaded hole.



NOTE: SURFACE HARDEN AND LIGHTLY VAPOR BLAST AFTER HEAT TREATING

SIZING TOOL FOR FIELD SERVICE REPLACEMENT OF "LOK-THREAD" BUSHINGS IN MAGNESIUM ALLOYS

COARSE THREAD SERIES

THREAD SIZE	PITCH DIA. AT "A"	PITCH DIA. AT "B"	THREAD LENGTH L
10-24	0.1557	0.1642-0.1653	
1/4-20	0.2093	0.2191-0.2201	0.625
5/16-18	0.2673	0.2784-0.2794	0.750
3/8-16	0.3244	0.3366-0.3376	0.875
7/16-14	0.3800	0.3937-0.3947	
1/2-13	0.4382	0.4527-0.4537	
9/16-12	0.4957	0.5114-0.5124	
5/8-11	0.5525	0.5692-0.5702	
3/4-10	0.6703	0.6885-0.6895	

NOTE:
THE THREAD LENGTH "L" FOR THE SIZING TOOLS IS GIVEN IN THE SIZES WHICH ARE NOW BEING USED.

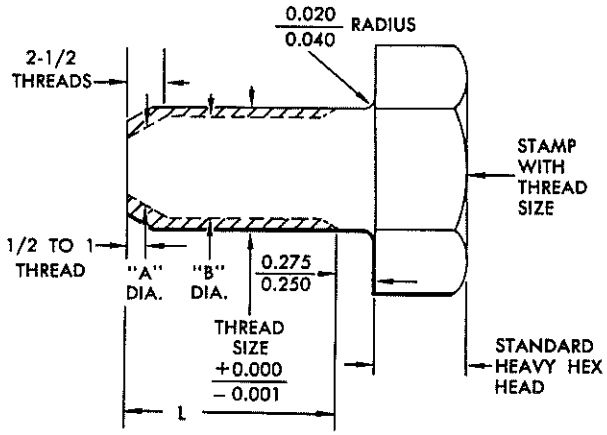
CJ805-3097-1-B1

Lok-Thread Sizing Tool
Figure 5

B. Use sizing tool to recondition the threaded hole. This tool forces the metal of threads to flow to the original pitch and minor diameters of the tapped hole (figure 5).

CAUTION: UNLESS THIS THREAD SIZING TOOL IS USED, THE BREAK-AWAY TORQUE WILL BE MUCH LESS THAN REQUIRED.

C. Treat the threaded hole with dichromate solution.



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CAUTION: UNLESS THIS THREAD SIZING TOOL IS USED, THE BREAK-AWAY TORQUE WILL BE MUCH LESS THAN REQUIRED.

C. Treat the threaded hole with dichromate solution.

D. Coat the external threads with zinc chromate primer.

E. Lubricate threaded hole with Alcoa's thread lube (Aluminum Company of America, 1501 Alcoa Building, Pittsburgh, Pa.), or equivalent.

F. Install new Lok-Thread stud. (Refer to Illustrated Parts Catalog for standard and oversize studs.)

(1) Use a locally fabricated tool for driving studs.

(2) Stud torque values are as follows:

0.250-inch diameter	40-140 lb-in.
0.3125-inch diameter	75-250 lb-in.
0.375-inch diameter	100-400 lb-in.

(3) Drive studs to required depth and height.

NOTE: Hole and stud must be free of burrs and foreign material to prevent binding during installation. Studs may be cadmium plated 0.005-0.010 inch oversize, if necessary, for installation.

(4) If stud cannot be replaced, use a special stud of local fabrication. (Refer to para. 7.)

7. Installation of Special Studs. The following is recommended for installing special studs to damaged holes.

A. Prepare damaged hole for next standard size National Coarse Thread.

(1) Drill to attain 75 to 85 percent thread.

(2) Tap, using an American Standard Coarse Class III tap. (The hole may be slightly countersunk before tapping.)

B. Fabricate a stepped stud to fit newly tapped hole. Use AMS 6327, steel bar stock. Inspect and cadmium plate per AMS 2400.

C. Corrosion protect the threaded hole.

D. Coat the external and internal threads with zinc chromate primer, specifications MIL-P-6889A, or Loctite Sealant, Grade "A" (American Sealant Co., Hartford 6, Conn.).

E. Install stud with shoulder step 0.005 to 0.020 inch below the surrounding surface.

F. Drill and install lock pin.

G. Peen metal over head of pin.

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C. Corrosion protect the threaded hole.

D. Coat the external and internal threads with zinc chromate primer, specifications MIL-P-6889A, or Loctite Sealant, Grade "A" (American Sealant Co., Hartford 6, Conn.).

E. Install stud with shoulder step 0.005 to 0.020 inch below the surrounding surface.

F. Drill and install lock pin.

G. Peen metal over head of pin.

8. 410 Welding Procedure.

A. Repairs shall be performed by welders trained and certified for 410 welding.

B. Remove all scale, grease and other foreign material from the area to be welded.

C. Cracks that do not extend to both surfaces should be completely removed by grinding. Through-cracks should be prepared by grinding as follows:

Stock Thickness	Preparation
up to 0.045 inch	Grind to 50 percent of parent metal thickness
0.045 to 0.090	Grind to 75 percent of parent metal thickness
0.090 to 0.250	Grind to within 0.030 inch of opposite surface

NOTE: All cracks to be removed by grinding, and checked by spot fluorescent-penetrant method, per 70-30-2, to ensure crack is completely removed.

D. Use the inert arc process of welding as follows:

NOTE: Material 0.125 inch or over will be preheated to 550°F (288°C) plus or minus 50° with an oxyacetylene torch using a neutral flame prior to welding. Tempilsticks (Tempil Corporation, 132 West 22 Street, New York, New York) or equivalent, of proper temperature range, will be used to ensure that the area is heated within the correct temperature range.

(1) Filler material - AMS 5776

(2) Electrode - 1/16-inch diameter tungsten, pointed

(3) Shielding - Argon at approximately 10 cubic feet per hour

(4) Backup - Argon gas at approximately 15 cubic feet per hour or copper

(5) Amperage requirements as follows:

Nominal Stock Thickness	Amperage
up to 0.045	30 - 40
0.045 - 0.065	50 - 60
0.065 - 0.080	60 - 80
0.080 - 0.250	80 - 100

NOTE: A remote control, variable current device should be employed to minimize heat input. Arctrol (Mullenback Electrical Manufacturing Co., P. O. Box 15436, 2300 East 27th Street, Los Angeles, Calif.), or equivalent, is recommended.

E. Each repair weld will be stress-relieved locally, by the following procedure.

CAUTION: ONLY PROPERLY TRAINED AND QUALIFIED PERSONNEL SHALL PERFORM THE FOLLOWING LOCALIZED STRESS RELIEF PROCEDURE.

(1) Localized torch stress relieving shall be preformed with an oxygen-acetylene torch with the following settings:

Stock Thickness	Torch Tip Orifice	Oxygen and Acetylene Pres.	Flame
up to 0.093	0.0380	2 psi	Neutral
0.093 - 0.250	0.0465	4 psi	Neutral

(2) Heat the repair-welded area and heat-affected zones to 1200°F (649°C). Heating is to be intermittent and controlled.

(3) Use 1150°F (621°C), 1200°F (649°C) and 1250°F (677°C) Tempilsticks to determine temperatures of metal during stress relieving.

(4) Maintain a temperature between 1150°F (621°C) and 1250°F (677°C) for 3 minutes, timed by an accurate clock. This time is to commence when heated area reaches 1200°F (649°C). The temperature will be controlled within these limits by the use of Tempilsticks.

(5) Allow part to cool to room temperature.

F. Use a stainless steel wire brush on the stress-relieved area to remove all scale and Tempilstick residue.

G. Inspect repaired area by magnetic-particle or the spot fluorescent-penetrant method.

9. A-286 Weld Procedure.

A. Repairs shall be performed by welders trained and certified for A-286 welding.

B. Remove all scale, grease and other foreign material from the area to be welded.

C. Cracks that do not extend to both surfaces should be completely removed by grinding. Through-cracks should be prepared by grinding as follows:

Stock Thickness	Preparation
to 0.045 inch	Grind to 50 percent of parent metal thickness.
0.045 to 0.090 inch	Grind to 75 percent of parent metal thickness.
0.090 inch and larger	Grind to within 0.030 inch of opposite surface.

D. Use the inert arc process of welding as follows:

(1) Filler material - Hastelloy "W" (AMS 5786).

(2) Shielding gas - Argon at approximately 10 cubic feet per hour.

(3) Amperage requirements as follows:

Nominal Stock Thickness	Amperage
up to 0.045	30 - 40
0.045 - 0.065	50 - 60
0.065 - 0.080	60 - 80
Castings	60 - 80

NOTE: A remote-control, variable current device should be employed to minimize heat input. Arctrol (Mullenback Electrical Manufacturing Co., P.O. Box 25436, 2300 East 27th Street, Los Angeles, Calif.) or equivalent, is recommended.

E. Where necessary, welding should be performed in a sequence that will minimize stress introduced during welding.

F. Copper backup and/or argon gas shielding should be employed whenever possible. If it is impossible to use both, make every effort to use one.

G. In multipass welding, each pass should be cleaned by grinding before the next pass is made.

H. If a crack extends into a rivet hole, remove rivet before welding. Grind welds flush and ream rivet hole before replacing rivet.

I. Clean repair welds with a fine emery cloth and spot fluorescent-penetrant inspect for cracks.

REFINISHING PROCEDURES

1. General. Refinishing is used to prevent corrosion on many parts on a jet engine. The finishes that can be applied at the maintenance level will be described. They are classified as touch-up finishes, and they can be applied with a minimum preparation and effort. Listed below are these finishes and some of their uses.

   A. Touch-up dichromate: Used on magnesium parts such as gear cases and compressor front frame.

   B. Touch-up chemical film coating: Used on aluminum and aluminum alloy parts, such as variable vane actuating rings, variable vane master rod, etc.

   C. Touch-up Silicone Aluminum paint: Used on Chromoloy parts, such as compressor stator casing, outer combustion casing and compressor rear frame.

2. Touch-up Dichromate Procedure.

   A. Touch-up dichromate may be applied as follows:

      (1) Clean areas to be touched up with clean cloth soaked in acetone or equivalent solvent which will not leave an oil film or residue.

      WARNING: ACETONE IS INFLAMMABLE. DO NOT USE NEAR OPEN FLAME. TREAT CLOTHS SOAKED IN ACETONE AS FIRE HAZARDS.

      (2) Brush generous amounts of dichromate touch-up solution on cleaned surfaces. Allow to stand for one minute; on welded areas for 3 minutes.

      (3) Rinse thoroughly with clean, cold water. Brush area lightly while rinsing. Properly treated parts are slightly iridescent with red and yellow shades predominating. If the touched-up area does not develop the color of adjacent areas, repeat the procedure until proper color is obtained.

3. Touch-Up Chemical Film Coating.

   A. The touch-up chemical film coating process is as follows:

      (1) Clean areas to be touched up with cloth soaked in volatile solvent.

      (2) Apply Turcoat No. 4178 solution (Turco Products, 62nd and Central Ave., Los Angeles 1, Calif.) or equivalent several times to the area to be retouched with a nylon bristle brush. Allow solution to react for 7-10 minutes. (Parts should acquire an iridescent greenish-golden color.)

      (3) If coating is powdery, treatment time is too long. Powder may be removed with a clean dry cloth without damage to coating.

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      (3) If coating is powdery, treatment time is too long. Powder may be removed with a clean dry cloth without damage to coating.

(4) The touch-up solution is made up as follows:

(a) Turcoat No. 4178 - 3 oz. per gallon of water. (Use polyethylene container.)

(b) Concentrated nitric acid - 1/2 fluid oz. per gallon of solution.

WARNING: USE PROTECTIVE CLOTHING AND POLYETHYLENE CONTAINERS WHEN HANDLING TURCOAT NO. 4178 POWDER OR NITRIC ACID. IF EITHER IS SPILLED ON SKIN, WASH IT OFF IMMEDIATELY WITH WATER. TREAT CLOTHS AND BRUSHES USED IN TURCOAT NO. 4178 AS FIRE HAZARDS.

4. Touch-Up Silicone Aluminum Paint Procedure.

NOTE: Painting chromoloy parts is optional.

A. Remove loose particles of paint and clean area with a wire brush. Wipe clean with a clean rag saturated with Xylol (Standard Oil Co., or equivalent). Do not touch or handle with bare hands any areas that have been prepared for touchup.

B. Brush or spray bare areas with one coat silicone aluminum paint*. Allow to air dry until the part can be handled or touched without smearing the paint.

NOTE: This paint is not fuel resistant until the part has been run on the engine to cure the paint.

*Sherwin Williams Heat Resisting Aluminum G66SC69, Sherwin Williams Co.

*Dixon Therocone Heat Resisting Paint No. 909 Aluminum, Joseph Dixon Crucible Co., Jersey City 3, New Jersey.

STANDARD TORQUE VALUES

1. General. Included in this section are standard torque values. These values will be used when the torque value is not given in the procedure for an operation. Minimum and maximum values are given for all classes of torque except "Fittings with gaskets". When castle nuts or tab lockwashers are used torque to the minimum value listed, and tighten to the next locking position.

2. Procedure. Seat mating parts properly, and run nuts and bolts down in a staggered sequence. Tighten nuts or bolts at diametrically opposite point where applicable. After parts are properly seated, apply fine tightening in a series of gradually increasing values until required torque is obtained.

   CAUTION: DO NOT EXCEED MAXIMUM TORQUE VALUES DURING SEATING PROCESS, SINCE OVERSTRESSING OR DISTORTION MAY RESULT.

3. Deleted.

4. Deleted.

5. Standard Torque Values for Steel Bolts and Nuts. The following table contains the dimensions of the steel bolts and nuts (including self-locking) and their standard torque values:

	UNC AND 8 SERIES		UNF AND 12 SERIES	
SIZE	THREADS PER INCH	TORQUE	THREADS PER INCH	TORQUE
.164	32	13-16 Lb.In.	36	16-19 Lb.In.
.190	24	20-23 Lb.In.	32	24-27 Lb.In.
.250	20	40-60 Lb.In.	28	55-70 Lb.In.
.3125	18	79-110 Lb.In.	24	100-130 Lb.In.
.375	16	160-210 Lb.In.	24	190-230 Lb.In.
.4375	14	250-320 Lb.In.	20	300-360 Lb.In.
.500	13	420-510 Lb.In.	20	480-570 Lb.In.
.5625	12	48-57 Lb.Ft.	18	55-65 Lb.Ft.
.625	11	70-80 Lb.Ft.	18	82-95 Lb.Ft.
.750	10	135-150 Lb.Ft.	16	150-165 Lb.Ft.
.875	9	205-230 Lb.Ft.	14	235-265 Lb.Ft.
1.000	8	300-340 Lb.Ft.	14	350-400 Lb.Ft.
1.125	7	415-480 Lb.Ft.	12	485-565 Lb.Ft.
1.250	7	600-700 Lb.Ft.	12	690-800 Lb.Ft.
1.500	6	1000-1200 Lb.Ft.	12	1200-1400 Lb.Ft.
1.125	8	440-510 Lb.Ft.		
1.250	8	625-725 Lb.Ft.		
1.500	8	1150-1350 Lb.Ft.		

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.164	32	13-16 Lb.In.	36	16-19 Lb.In.
.190	24	20-23 Lb.In.	32	24-27 Lb.In.
.250	20	40-60 Lb.In.	28	55-70 Lb.In.
.3125	18	79-110 Lb.In.	24	100-130 Lb.In.
.375	16	160-210 Lb.In.	24	190-230 Lb.In.
.4375	14	250-320 Lb.In.	20	300-360 Lb.In.
.500	13	420-510 Lb.In.	20	480-570 Lb.In.
.5625	12	48-57 Lb.Ft.	18	55-65 Lb.Ft.
.625	11	70-80 Lb.Ft.	18	82-95 Lb.Ft
.750	10	135-150 Lb.Ft.	16	150-165 Lb.Ft.
.875	9	205-230 Lb.Ft.	14	235-265 Lb.Ft.
1.000	8	300-340 Lb.Ft.	14	350-400 Lb.Ft.
1.125	7	415-480 Lb.Ft.	12	485-565 Lb.Ft.
1.250	7	600-700 Lb.Ft.	12	690-800 Lb.Ft.
1.500	6	1000-1200 Lb.Ft.	12	1200-1400 Lb.Ft.
1.125	8	440-510 Lb.Ft.		
1.250	8	625-725 Lb.Ft.		
1.500	8	1150-1350 Lb.Ft.		

(4) The touch-up solution is made up as follows:

(a) Turcoat No. 4178 - 3 oz. per gallon of water. (Use polyethylene container.)

(b) Concentrated nitric acid - 1/2 fluid oz. per gallon of solution.

WARNING: USE PROTECTIVE CLOTHING AND POLYETHYLENE CONTAINERS WHEN HANDLING TURCOAT NO. 4178 POWDER OR NITRIC ACID. IF EITHER IS SPILLED ON SKIN, WASH IT OFF IMMEDIATELY WITH WATER. TREAT CLOTHS AND BRUSHES USED IN TURCOAT NO. 4178 AS FIRE HAZARDS.

4. Touch-Up Silicone Aluminum Paint Procedure.

NOTE: Painting chromoloy parts is optional.

A. Remove loose particles of paint and clean area with a wire brush. Wipe clean with a clean rag saturated with Xylol (Standard Oil Co., or equivalent). Do not touch or handle with bare hands any areas that have been prepared for touchup.

B. Brush or spray bare areas with one coat silicone aluminum paint*. Allow to air dry until the part can be handled or touched without smearing the paint.

NOTE: This paint is not fuel resistant until the part has been run on the engine to cure the paint.

*Sherwin Williams Heat Resisting Aluminum G66SC69, Sherwin Williams Co.

*Dixon Therocone Heat Resisting Paint No. 909 Aluminum, Joseph Dixon Crucible Co., Jersey City 3, New Jersey.

Tube OD	Thread Size	Nut (AN924) Union (AN815)	Plug (AN814)	Nut (AN6289)	Torque Units
0.375	0.5625-18	100-150	80-120	150-200	lb-in.
0.500	0.750-16	180-230	150-200	200-250	lb-in.
0.625	0.875-14	250-350	200-350	275-400	lb-in.
0.750	1.0625-12	420-600	300-500	450-650	lb-in.
1.000	1.3215-12	50- 70	38- 50	55- 75	lb-ft.
1.250	1.625-12	60- 80	50- 60	65- 85	lb-ft.
1.500	1.875-12	70- 90	50- 70	75- 90	lb-ft.

8. Standard Torque Values for Jam Nuts of Fittings without Gaskets. The following table contains the dimensions of fittings and their standard torque values.

Tube OD	Thread Size	Aluminum	Steel	Torque Units
0.125	0.3125-24	35- 50	-------	lb-in.
0.1875	0.375-24	65- 80	70- 90	lb-in.
0.250	0.4375-20	90-105	110-130	lb-in.
0.3125	0.500-20	105-125	140-160	lb-in.
0.375	0.5625-18	125-145	225-275	lb-in.
0.500	0.750-16	240-280	400-450	lb-in.
0.625	0.875-14	330-370	550-650	lb-in.
0.750	1.0625-12	45- 55	70- 80	lb-ft.
1.000	1.3215-12	70- 80	85-100	lb-ft.
1.250	1.625-12	80-100	-------	lb-ft.
1.500	1.875-12	100-120	-------	lb-ft.

NOTE: Use one-half of torque values listed above for thin steel hex nuts (those nuts having a height of less than 0.6 pitch diameter plain nuts and less than 0.8 pitch diameter for self-locking nuts), for nuts and bolts of alloys other than steel or for all bolts threaded directly into aluminum, magnesium or other non-ferrous alloys.

6. Standard Torque Values for Flared Tubing and Hose Fittings. The following table contains the dimensions of flared tubing and hose fittings and their standard torque values:

Tube OD	Thread Size	All Aluminum Parts	Steel Tubing Aluminum or Steel Nut	Torque Units
0.125	0.3125-24	--------	35- 40	lb-in.
0.1875	0.375-24	30- 50	90-100	lb-in.
0.250	0.4375-20	40- 65	135-150	lb-in.
0.3125	0.500-20	60- 80	180-200	lb-in.
0.375	0.5625-18	75-125	270-300	lb-in.
0.500	0.750-16	150-250	450-500	lb-in.
0.625	0.875-14	200-350	650-700	lb-in.
0.750	1.0625-12	25- 41	75- 83	lb-ft.
1.000	1.3125-12	41- 58	100-116	lb-ft.
1.250	1.625-12	50- 75	125-150	lb-ft.
1.500	1.875-12	50- 75	158-183	lb-ft.

7. Standard Torque Values for Fittings and Gaskets. The following table contains the dimensions of the fittings with gaskets and their standard torque values:

Tube OD	Thread Size	Nut (AN924) Union (AN815)	Plug (AN814)	Nut (AN6289)	Torque Units
0.125	0.3125-24	25- 35	10-16	25- 35	lb-in.
0.1875	0.375-24	50- 75	30-40	50- 75	lb-in.
0.250	0.4375-20	55- 80	40-65	75-100	lb-in.
0.3125	0.500-20	75-100	60-80	90-120	lb-in.

ENGINE PRESERVATION

1. General. This section contains the procedure for preservation of an engine, and service required while in the preserved state.

   One reason for preserving an engine is to prevent rust while the engine is in storage or in transit. Since rust is caused primarily by 2 factors, (1) the effect of corrosive liquids and gases on metals, and (2) electro-chemical action, the procedures listed will deal primarily with moisture control. Any dehydration technique must keep relative humidity below 40 percent in order to be effective.

   The preservation procedures cover periods of 1 to 10 days, 10 to 30 days, 30 to 120 days and 120 days or longer. A one-year limitation is placed on engine storage. If the one-year period is exceeded, the engine must be completely disassembled and inspected, and all engine controls and accessories bench-checked prior to use.

   NOTE: Regardless of the reason, whether storage or repair, engines that are not in operation should be preserved in accordance with one of the following procedures.

2. Preservation Procedure - 1 to 20 Days. If the engine is prepared for storage not to exceed 20 days, the following procedure is required.

   A. Seal the front frame, aft fan inlet, and the exit of the aft fan with moisture barrier covers.

   B. Seal all the strut openings.

3. Preservation Procedure - 20 to 30 Days. If the engine is removed from the aircraft and is prepared for shipment or storage not to exceed 30 days, the following procedure must be observed.

   A. Rotate the engine at approximately 15 percent. Turn off power supply. Spray one quart of oil (same as used in engine lubricating system, 72-5-0) into the compressor inlet while the engine is rotating.

   B. Place dessicent container and humidity indicator in the engine inlet and exit. Seal the inlets and exits with a moisture barrier. Seal all other engine openings.

      CAUTION: MAKE CERTAIN THAT THE STRUT OPENINGS ARE SEALED.

4. Preservation Procedure - 30 to 120 Days. The following procedure will prepare an engine for storage up to 120 days.

A. Attach a line from a supply of 1010 oil (Specification MIL-O-6081A or equivalent) to the fuel pump inlet port. The capacity of the 1010 oil reservoir must be at least 12 gallons.

B. Disconnect the fuel drain line and fuel manifold lines at the pressurizing and drain valve. Attach lines to P and D valve ports in such a way that any flow is directed back to the reservoir of 1010 oil.

C. Fill both compartments of the oil tank with engine as spedified in 72-5-0.

D. Move the fuel shutoff shaft to the full open position.

E. Using ground starting equipment, rotate the engine at approximately 15 percent. Turn-off power supply to ground starting equipment and spray one quart of engine oil (same as used in engine lubricating system, 72-5-0) into the compressor inlet while the engine is rotating.

F. After coastdown, move fuel shutoff shaft to closed position.

NOTE: Proper scavenging of the bearing sumps occurs during engine coastdown.

G. Remove ground starting equipment.

H. Disconnect the 1010 oil supply line from the fuel pump. Cap the pump inlet.

I. Disconnect the 1010 oil return lines from the P and D valve. Connect the fuel drain line and manifold lines to the valve.

J. Place desiccant container and humidity indicator in engine and fan inlet and exit. Seal the inlet and exit openings with a moisture barrier. Seal all other engine openings.

CAUTION: MAKE CERTAIN THAT THE STRUT OPENINGS ON THE FAN FRAMES ARE SEALED.

K. At 30-day intervals the following steps should be repeated:

(1) Remove the moisture barriers and the desiccant containers from the engine inlet and exit.

(2) Place a direct-reading pressure indicator at the customer's lube oil transmitter sensing line.

(3) Rotate the engine to a speed where a positive indication of oil pressure is indicated.

CAUTION: DO NOT EXCEED 4 TO 7 PERCENT RPM. HIGHER RPM WILL CAUSE PRESERVATION OIL TO FLOW THROUGH FUEL NOZZLE INTO COMBUSTION SECTION.

(4) Allow the engine to coast down, remove the gage.

(5) Check the humidity indicator, and replace desiccant containers if necessary.

(6) Place the desiccant containers and indicators in the engine and fan inlet and exit of engine. Seal the engine and fan inlet and exit with moisture barriers.

5. Extended Storage of Engine.

A. General. The following procedure will prepare an engine for storage up to one year.

B. Perform the preservation procedure described in paragraph 4, item A thru I.

C. Drain the oil tank.

D. Install the engine in shipping container.

(1) Remove lid of shipping container.

(2) Check container for rust and loose paint. Remove rust, and repaint any place which needs touching up. Wipe or vacuum-clean the inside of the container to ensure cleanliness. Attach a sling with hoist to the container yoke at the two lift points.

(3) Remove the bolts which secure the yoke to the container side rail and lift yoke from container.

(4) Remove pins from yoke and raise yoke over engine; then slowly lower yoke until unibal pin engages unibal in front engine mount.

(5) After unibal is engaged continue to lower hoist until hanger bars of yoke are lined up with holes in front engine mount. Install pins and secure with cotter pins.

(6) Install aft mount of yoke to the fan frame behind and below the fan frame lift eye. Install pin and secure with nut. Torque nut to 100 lb-in.

(7) Remove hoist and sling from yoke.

(8) Install lift adapter 2C4454 on the 12 o'clock pad on the engine front frame.

(9) Connect a hoist to the front frame lift adapter.

(10) Connect a second hoist to the aft lift eye of the yoke.

(11) Apply tension on the two hoists and remove the stand attaching brackets.

(12) Raise the engine from the stand, and move it to a position over the shipping container.

(13) Lower the engine into the container, using care to align dowel pins in side rails with the holes in yoke bases and secure bolts, nuts, and washers.

(14) Torque all mounting bolts.

(15) Remove lift adapter from front frame.

(16) Install cover plate and gasket to front frame pad.

(17) Install dust covers on the engine and fan inlet and exits.

(18) Place 30 bags of dessicant into the basket in the container.

(19) Check the gasket around the flange of the container.

(20) Place the lid of the container in position.

(21) Install and torque all nuts and bolts.

(22) Pressurize the container through the air filler valve with dry air or nitrogen to 5 psig.

(23) Perform a soap check on the flange of the container for leaks.

E. A periodic inspection will be performed every 120 days. If pressure is less than 1 psig and humidity indicator shows SAFE (blue), repressurize to 5 psig with dry air. If pressure is less than 1 psig and humidity indicator shows UNSAFE (pink), remove filler valve and release remaining pressure. Remove container cover and check engine for corrosion. If corrosion is not evident, place new dessicant in container and repressurize. If severe corrosion exists, repressurize container and return engine to overhaul.

6. Depreservation Procedures.

A. Removal of engine from shipping container. Use the following procedure:

(1) Loosen the core in the air filler valve and permit the pressurized air or nitrogen to bleed from the container.

(2) Remove the bolts from around the horizontal flanges of the container.

(3) Using an overhead hoist and sling, carefully remove the container lid.

(4) Remove dust covers from each end of the engine, and remove the cover from the lifting pad at 12 o'clock on the front frame.

(5) Install lift adapter, 2C4454 on the 12 o'clock pad on the engine front frame.

(6) Connect a hoist to front frame lift adapter.

(7) Connect a second hoist to aft lift eye of the yoke.

(8) Apply slight tension to the hoist. Remove the bolts that secure the yoke to the side rails of the container.

CAUTION: TENSION MUST BE KEPT ON HOISTS AT ALL TIMES WHEN ENGINE IS IN CONTAINER WITH THE CROSSBEAMS REMOVED.

(9) Carefully raise the engine from the container and place into engine work stand. Remove hoist from front frame adapter.

(10) Remove the lift adapter 2C4454 from front frame and replace cover on 12 o'clock pad. Remove pins attaching yoke to engine and remove yoke.

(11) Install yoke in shipping container and secure with bolts.

CAUTION: BE CERTAIN THAT THE VALVE CORE OF AN UNPRESSURIZED CONTAINER IS REMOVED BEFORE STORING OR SHIPPING EMPTY CONTAINER. OTHERWISE, THE CONTAINER MAY COLLAPSE.

B. Depreservation of the lube system is not required as it is preserved with engine oil. Check both compartments of the oil tank for proper quantity and service as specified in 72-5-0.

C. The fuel system is depreserved by performing a wet prestart (without ignition). Move the fuel shut-off shaft to the full open position and motor engine for 15 seconds or until fuel flow is observed.

ACCESSORY PRESERVATION

1. General. If an accessory is removed from the engine and placed in spare parts stock, it must be properly prepared for storage. By observing normal practices of proper packaging and performing the following preservation procedures all engine accessories can be stored without detrimental effects.

2. Fuel System Components.

   A. If component has been subjected to commercial kerosene, as in engine operation, it can be stored for periods up to 30 days by draining excess fluid, installing protective covers over drive shafts and control shafts, and capping all openings.

   B. To store components for periods in excess of 30 days, the component should be flushed with MIL-O-6081, grade 1010 oil. Drain excess fluid, install protective covers over drive shafts and control shafts, and cap all openings.

3. Lubrication System Components. Perform the following procedure to preserve lube system components.

   A. Pour a sufficient amount of engine oil (same as used in engine lubricating system, 72-5-0) into the component to coat the internal parts. Rotate the drive shaft of engine driven components to assure a thorough coating of oil.

      NOTE: If the component has been subjected to engine oil, as in engine operation or testing, this is sufficient to coat the internal mechanisms.

   B. Drain excess fluid.

   C. Cap all openings.

   D. Install protective covers over drive shafts.

4. Electrical Components. To store electrical components, install protective covers on amphenol connectors and drives.

5. Air System Components. To store air system components, install caps on all openings.

INSPECTION METHODS

1. Spot Method of Post Emulsion - Penetrant Inspection. The use of this method is not intended as a substitute for the standard method of post emulsion-penetrant inspection. However, it is considered an acceptable alternate process for the detection of surface defects after repair operations to remove known defects, or for the inspection of isolated area when it is not considered practical to process the entire part.

   A. Materials and Equipment Required.

      (1) Post emulsification fluorescent-penetrant oil (ZL-2 or ZL-22, Magnablux Corp., or equiv.).

      (2) Cleaner (spray can used in Red Dye Penetrant Inspection, Magnaflux Corp. or equiv.).

      (3) Developer (ZD-4, or spray can used in red-dye-penetrant inspection, Magnaflux Corp. or equiv.).

      (4) Black light equipped with canvas hood and viewing slot. (Magnaflux Corp. or equiv.)

   B. The Procedure.

      (1) Parts should be thoroughly cleaned by a process that will remove all traces of scale, carbon, grease and oils or other foreign matter. Parts that have been reworked to remove known defects must be vapor blasted (on the reworked area) or given a light acid etch to remove metal particles, since these particles may interfere with the penetration of the penetrant oil into possible remaining defects. Failure to comply with this provision of the procedure may nullify inspection results.

      (2) Apply penetrant oil (ZL-2 or ZL-22) to areas to be inspected. Penetrant oil may be applied by either brushing or spraying.

      WARNING: IF PENETRANT OIL IS APPLIED BY SPRAYING, PRECAUTIONS SHOULD BE TAKEN TO PREVENT FIRE HAZARDS. THE FLASH POINT OF THE PENETRANT OIL IS LOWERED CONSIDERABLE WHEN USED AS A FINE SPRAY.

      (3) Allow penetrant oil to remain on parts for a minimum period of 15 minutes.

      (4) Remove excess penetrant oil from surface of part by brushing or spraying the area with the cleaner used in the Red Dye-Penetrant Inspection Kit.

      (5) Inspect area with black light to ensure complete removal of excess penetrant oil.

(6) Apply developer.

NOTE: The ZP-4 Fluffy Dry Powder provides the greatest sensitivity and can be applied by brushing or any other means of application that will provide coverage of the area to be inspected. The wet developer, also included in the Red Dye Penetrant Inspection Kit, may be used as an alternate when a wet developing method is desired.

(7) Allow a minimum period of 5 minutes for proper development of indications.

(8) Place hooded canvas area of black light directly over area to be inspected. View area through slot provided for this purpose.

NOTE: Parts may be inspected in black light inspection booth if conditions permit.

(9) Encircle defective areas with suitable identification, such as Red Dykem or chalk.

2. Macroetch (Swab Type).

A. The acid etching soltuion should be mixed in a plastic container partially submerged in water and should be mixed in the order listed. Composition of the solution is as follows:

75cc	Water
15cc	Sulphuric Acid (95-98%)
180cc	Hydrochloric Acid (36.5-38% CP Grade)
50cc	Nitric Acid (69-71% CP Grade)
75cc	Acetic Acid (99.7%)
45 grams	Ferric Chloride ($FeCl_3.6H_2O$-ACS)

NOTE: The ferric chloride should be liquified by melting in a stainless steel container over a low flame prior to mixing.

B. Apply the etching solution to the reworked area with a clean cotton tipped swab. Allow the solution to remain on the reworked area for 1 to 1-1/2 minutes.

WARNING: SEVERE BURNS WILL RESULT IF THE ETCHING SOLUTION COMES IN CONTACT WITH THE SKIN. PRECAUTIONS SHOULD BE TAKEN TO AVOID SKIN CONTACT WITH THIS SOLUTION.

C. Wash all acid etched areas thoroughly with water and dry the surface before proceeding with the inspection.